Docket No.: 030048094US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Kelley-Wickemeyer et al.

Application No.: 10/671,435

Confirmation No.: 2918

Filed: September 24, 2003

Art Unit: 3643

For: AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL

Examiner: R.P. Swiatek

PETITION UNDER 37 CFR 1.47(A)

MS Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action mailed June 29, 2011, Applicant respectfully submits the following:

A. Petition under 37 C.F.R. § 1.47(a) in the above identified application;

B. Petition fee of $200 under 37 C.F.R. § 1.17(g);

C. Attachment A – Declaration of Paula Quinanola filed in support of Petition under 37 C.F.R. § 1.47(a); and

D. Petition for a Two Month Extension of Time under 37 C.F.R. § 1.117(a)(3).

A. Petition under 37 C.F.R. § 1.47(a) in which a joint inventor cannot be reached or refuses to join

Robert H. Kelley-Wickemeyer, Gerhard E. Seidel, Peter Z. Anast, and James Douglas McLean are joint inventors in the above-identified application ("the Application"). This Petition under 37 C.F.R. § 1.47(a) is made on behalf of The Boeing Company, the assignee of all right, title and interest in the invention described and claimed in the application, because Mr. McLean has not responded to diligent efforts to reach him.

1. The last known address for Mr. McLean is:

7004 South 130th Street
Seattle, Washington 98178-4718

2. Mr. McLean was an employee of The Boeing Company at the time the parent application (U.S. 09/284,122) was filed on April 5, 1999.

3. Mr. McLean assigned the Application to The Boeing Company on September 19, 2003 in an assignment recorded at Reel 014580 / Frame 0610.

4. To date, Mr. McLean has not responded to diligent efforts to contact him and has not provided an executed supplemental reissue declaration. The circumstances of the presentation of application papers, and the unavailability of Mr. McLean are evidenced by the statement of facts set forth in the attached Declaration of Paula Quinanola (Attachment A) filed in support of this Petition under 37 C.F.R. § 1.47(a) and summarized below.

a) The application, declaration, and a copy of Non-Final Office Action were sent to Mr. McLean on October 14, 2011 via U.S. Postal Service Certified Mail. The package was received by Mr. McLean on October 15, 2011. Domestic Return Receipt was required and was signed by Mr. James McLean.

b) Mr. McLean was again presented with the application papers via U.S. Postal Service Certified Mail in a letter sent on November 10, 2011. Domestic Return Receipt was required and the package was received/signed by Ms. Theresa McLean on November 16, 2011;

c) As of today's date (November 29, 2011) I have not received a response to either of the foregoing communications to Mr. McLean.

5. A timely response to an outstanding Office Action is necessary to preserve the rights of The Boeing Company to prevent irreparable damage to The Boeing Company.

Based on the above and Attachment A, Applicant respectfully requests the Commissioner to grant this Petition under 37 C.F.R. 1.47(a).

B. Petition for a Two Month Extension of Time under 37 C.F.R. § 1.136(a)

A separate petition for a two month extension of time and the requisite fee under 37 C.F.R. § 1.17(a) accompany this response.

Please charge our credit card in the amount of $560.00 covering the fee set forth in 37 CFR 1.117(a)(2), and $200 covering the petition fee under 37 CFR 1.17(g).. The Director is hereby authorized to charge any deficiency in the fees

filed, asserted to be filed or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our Deposit Account No. 50-0665, under Order No. 030048094US.

Dated: November 29, 2011

Respectfully submitted,

By________________________

John M. Wechkin
Registration No.: 42,216
PERKINS COIE LLP
P.O. Box 1247
Seattle, Washington 98111-1247
(206) 359-3257
(206) 359-4257 (Fax)
Attorney for Applicant

ATTACHMENT A

Declaration of Paula Quinanola with Exhibits A-D

Docket No.: 030048094US
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of:
Kelley-Wickemeyer et al.

Application No.: 10/671,435 | Confirmation No.: 2918

Filed: September 24, 2003 | Art Unit: 3643

For: AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL | Examiner: R.P. Swiatek

DECLARATION OF PAULA QUINANOLA FILED IN SUPPORT OF PETITION UNDER 37 C.F.R. § 1.47(A)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Paula Quinanola, hereby declare and say that:

1. I am a paralegal at the law firm of Perkins Coie, LLP, the authorized attorney of record for The Boeing Company, the owner of U. S. Patent Application No. 10/671,435, a reissue application of U.S. Patent 6,293,497 , titled AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL, September 24, 2003, (the "Application").

2. I am familiar with and have knowledge and belief of the facts recited below.

3. James Douglas McLean (the "Inventor") is listed as a joint inventor of the invention as claimed in the Application.

4. On October 14, 2011, I sent to Mr. McLean, at his last known address, via U.S. Postal Service Certified Mail, a copy of the Reissue Application - U.S. Patent No. 6,293,497, a copy of the Non-Final Office Action, and a copy of the Supplemental Declaration by inventor. The letter requested Mr. McLean to sign the Supplemental Declaration, and respond by October 29, 2011. U.S. Postal Service confirms the package was delivered via Certified Mail and that Mr. McLean signed for the package on October 15, 2011. A copy of the letter and attachments are provided as Exhibit A. A copy of the confirmation of delivery (Domestic Return Receipt) is attached as Exhibit B.

5. On November 10, 2011, I sent a second letter to Mr. McLean at his last known address, via U.S. Postal Service Certified Mail, a copy of the Reissue Application - U.S. Patent No. 6,293,497, a copy of the Non-Final Office Action, a copy of the pending claims, and a copy of the Supplemental Declaration by inventor. U.S. Postal Service confirms the package letter was delivered. A copy of the letter and attachments are provided as Exhibit C. A copy of the confirmation of delivery (Domestic Return Receipt) is attached as Exhibit D.

6. As of the date of this Declaration, I have not received a response from Mr. McLean, and I have not received a signed Declaration from Mr. McLean.

The undersigned declares that all statements made herein of her own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false

statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or of any patent issued thereon.

Dated: November 29, 2011

Paula Quinanola
Patent Paralegal
Perkins Coie LLP
PO Box 1247
Seattle, WA 98111-1247

EXHIBIT A

Letter sent to James Douglas McLean on October 14, 2011, and attachments

Perkins Coie

1201 Third Avenue, Suite 4800
Seattle, WA 98101-3099
PHONE: 206.359.8000
FAX: 206.359.9000
www.perkinscoie.com

Paula M. Quinanola
PHONE: (206) 359-3093
EMAIL: PQuinanola@perkinscoie.com

October 14, 2011

CERTIFIED MAIL

James Douglas McLean
7004 South 130th Street
Seattle, WA 98178-4718

Re: U.S. Patent Application No. 10/671,435
Title: AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL
Boeing Reference No. 96-273B
Perkins Reference No. 03004.8094US00

Dear James:

We recently received an office action for the above-referenced reissue application. In the Office Action the Examiner requested we provide a supplemental declaration. Please sign and return the attached Declaration document to us by October 29, 2011. Please note this is the reissue application of issued U.S. Patent 6,293,497.

If you have any questions, please do not hesitate to contact us.

Best Regards,

Paula M. Quinanola
Paralegal

PMQ::pq

Enclosures:
 Supplemental Declaration
 Copy of Non-Final Office Action
 Copy of U.S. Patent 6,293,497

03004-8094.US00/LEGAL21934889.1

PTO/SB/51S (09-07)
Approved for use through 08/31/2013. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

SUPPLEMENTAL DECLARATION FOR REISSUE PATENT APPLICATION TO CORRECT "ERRORS" STATEMENT (37 CFR 1.175)		
	Attorney Docket Number	030048094US
	First Named Inventor	Robert H. Kelley-Wickemeyer
	COMPLETE if known	
	Application Number	10/671,435-Conf. #2918
	Filing Date	September 24, 2003
	Art Unit	3643
	Examiner Name	R. P. Swiatek

I/We hereby declare that:

Every error in the patent which was corrected in the present reissue application, and is not covered by a prior oath/declaration submitted in this application, arose without any deceptive intention on the part of the applicant.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

I/We hereby declare that all statements made herein of my/our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname	
Robert H.		Kelley-Wickemeyer	
Inventor's Signature		Date	
Name of Second Inventor:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname	
Gerhard E.		Seidel	
Inventor's Signature		Date	

☒ Additional inventors or legal representative(s) are being named on the 1 supplemental sheet(s) PTO/SB/02A or 02LR attached hereto.

PTO/SB/02A (07-07)
Approved for use through 09/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION	ADDITIONAL INVENTOR(S) Supplemental Sheet Page 1 of 1

Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Peter Z.		Anast	
Inventor's Signature			Date
Residence: City Bellingham	State WA	Country United States of America	Citizenship US
Mailing Address: 1323 Varsity Place			
City Bellingham	State WA	Zip 98225	Country United States of America
Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
James Douglas		McLean	
Inventor's Signature			Date
Residence: City	State	Country	Citizenship US
Mailing Address: 7004 South 130th Street			
City Seattle	State WA	Zip 98178	Country United States of America
Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Inventor's Signature			Date
Residence: City	State	Country	Citizenship
Mailing Address:			
City	State	Zip	Country

03004-8094.US00
JMW/PQ

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/671,435	09/24/2003	Robert H. Kelley-Wickemeyer	03004.8094US	2918

64066 7590 06/29/2011
PERKINS COIE LLP (BOEING)
P.O. BOX 1247
PATENT - SEA
SEATTLE, WA 98111-1247

REVIEWED
By Sam Beard at 9:02 am, Jun 29, 2011

Docketed:
3mo Due Date - 09/29/11
6mo Deadline - 12/29/11

EXAMINER	
SWIATEK, ROBERT P	

ART UNIT	PAPER NUMBER
3643	

NOTIFICATION DATE	DELIVERY MODE
06/29/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patentprocurement@perkinscoie.com

Office Action Summary	Application No.	Applicant(s)
	10/671,435	KELLEY-WICKEMEYER ET AL.
	Examiner	Art Unit
	Rob Swiatek	3643

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01 June 2011*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-37,39-48 and 50-78* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-37,39-48 and 50-78* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☒ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *6-19-09; 5-14-11; 6-1-11*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

The reissue declaration filed with this application is defective (see 37 CFR 1.175 and MPEP § 1414) because of the following: It does not state that applicant (1) believes the original patent to be partly inoperative or invalid by reason of the patentee claiming more than patentee had a right to claim in the patent *or* (2) believes the original patent to be partly inoperative or invalid by reason of the patentee claiming less than patentee had a right to claim in the patent. Where, however, a given independent claim is considered to be overly broad, and another independent claim is considered to be overly narrow, patentee has claimed both more *and* less than patentee had a right to claim. In this latter instance, both above-quoted statements would be used. Applicant's statement that the original patent is "wholly or partly inoperative or invalid . . . . by reason of the patentee claiming more or less than he had the right to claim in the patent" is improper because a claim cannot claim "more *or* less" at the same time.

In accordance with 37 CFR 1.175(b)(1), a supplemental reissue oath/declaration under 37 CFR 1.175(b)(1) must be received before this reissue application can be allowed.

Claims 1-37, 39-48, 50-78 are rejected as being based upon a defective reissue declaration under 35 U.S.C. 251. See 37 CFR 1.175. The nature of the defects is set forth above.

Receipt of an appropriate supplemental oath/declaration under 37 CFR 1.175(b)(1) that includes the "Every error . . . " language set forth below as well as language addressing statements (1) and (2) above will overcome this rejection under 35 U.S.C. 251. An example of acceptable language to be used in the supplemental oath/declaration is as follows:

> "Every error in the patent which was corrected in the present reissue application, and is not covered by a prior oath/declaration submitted in this application, arose without any deceptive intention on the part of the applicant."

See MPEP § 1414.01.

If the above rejection is overcome, claims 1-37, 39-48, 50-78 will be allowed.

/Rob Swiatek/

Primary Examiner, Art Unit 3643

Ph.: 571/272-6894
19 June 2011

PTO/SB/08b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	10/671,435-Conf. #2918
(Use as many sheets as necessary)				Filing Date	September 24, 2003
				First Named Inventor	Robert H. Kelley-Wickemeyer
				Art Unit	3643
				Examiner Name	R. P. Swiatek
Sheet	1	of	1	Attorney Docket Number	030048094US

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-1,785,620	12-16-1930	Frise	
		US-1,913,169	06-06-1933	Martin	
		US-2,502,315	03-28-1950	Earhart	
		US-2,549,760	04-24-1951	Adams	
		US-3,203,647	08-13-1965	Alvarez-Calderon	
		US-3,493,196	02-03-1970	McCall	
		US-3,583,660	06-08-1971	Hurkamp et al.	
		US-3,853,289	12-10-1974	Nevermann et al.	
		US-4,395,008	07-26-1983	Sharrock et al.	
		US-4,763,862	08-16-1988	Steinhauer et al.	
		US-4,834,326	05-30-1989	Stache	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
		EP-230061-A1	07-29-1987	Boeing Co		
		WO-9105699-A1	05-02-1991	Bell Helicopter Textron Inc		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		European Supplementary Search Report for European Patent Application No. EP97947269, search completed May 19, 2000, 1 page.	
		International Search Report for International Application No. PCT/US97/19048, mailed February 23, 1998, 3 pages	

Examiner Signature	/Robert P. Swiatek/	Date Considered	06/19/2011

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. * CITE NO.: Those application(s) which are marked with an single asterisk (*) next to the Cite No. are not supplied (under 37 CFR 1.98(a)(2)(iii)) because that application was filed after June 30, 2003 or is available in the IFW. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.P.S./

PTO/SB/08b (06-09)
Approved for use through 06/30/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	1	of	2

Complete if Known	
Application Number	10/671,435-Conf. #2918
Filing Date	September 24, 2003
First Named Inventor	Robert H. Kelley-Wickemeyer
Art Unit	3643
Examiner Name	R. P. Swiatek
Attorney Docket Number	030048094US

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number: Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-1,724,456	08-13-1929	Crook	
		US-2,086,085	07-06-1937	Lachmann et al.	
		US-2,138,952	12-06-1938	Blume	
		US-2,169,416	08-15-1939	Griswold	
		US-2,207,453	07-09-1940	Blume	
		US-2,282,516	05-12-1942	Hans et al.	
		US-2,289,704	07-14-1942	Grant	
		US-2,319,383	05-18-1943	Zap	
		US-2,347,230	04-25-1944	Zuck	
		US-2,383,102	08-21-1945	Zap	
		US-2,406,475	08-27-1946	Rogers	
		US-2,444,293	06-18-1943	Holt	
		US-2,518,854	08-15-1950	Badenoch	
		US-2,555,862	06-05-1951	Romani	
		US-2,563,453	08-07-1951	Briend	
		US-2,665,085	01-05-1954	Crocombe et al.	
		US-2,743,887	05-01-1956	Fiedler	
		US-2,938,680	05-31-1960	Greene et al.	
		US-3,203,647	08-31-1965	Alvarez-Calderon	
		US-3,486,720	12-30-1969	Seglem et al.	
		US-3,528,632	09-15-1970	Miles et al.	
		US-3,539,133	11-10-1970	Robertson	
		US-3,589,648	06-29-1971	Gorham et al.	
		US-3,642,234	02-15-1972	Kamber et al.	
		US-3,677,504	07-18-1972	Schwarzler et al.	
		US-3,767,140	10-23-1973	Johnson	
		US-3,776,491	12-04-1973	Oulton	
		US-3,874,617	04-01-1975	Johnson	
		US-3,897,029	07-29-1975	Calderon et al.	
		US-3,904,152	09-09-1975	Hill	
		US-3,917,192	11-04-1975	Alvarez-Calderon et al.	
		US-3,985,319	10-12-1976	Dean et al.	
		US-3,987,983	10-26-1976	Cole	
		US-4,049,219	09-20-1977	Dean et al.	
		US-4,172,575	10-30-1979	Cole	

Examiner Signature	/Robert P. Swiatek/	Date Considered	06/19/2011

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. * CITE NO.: Those application(s) which are marked with an single asterisk (*) next to the Cite No. are not supplied (under 37 CFR 1.98(a)(2)(iii)) because that application was filed after June 30, 2003 or is available in the IFW. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

03004-8094.US00/LEGAL16397201.1

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.P.S./

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 2 of 2

Complete if Known	
Application Number	10/671,435-Conf. #2918
Filing Date	September 24, 2003
First Named Inventor	Robert H. Kelley-Wickemeyer
Art Unit	3643
Examiner Name	R. P. Swiatek
Attorney Docket Number	030048094US

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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		FR-56121	09-17-1952	Holste		
		FR-57 988	09-18-1953	Lemoigne		
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		FR-705155	06-02-1931	Bechereau Louis		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		WHITCOMB, RICHARD T., "Review of NASA Supercritical Airfoils," National Aeronautics and Space Administration, August 1974 (pages 8-18)	

Examiner Signature	/Robert P. Swiatek/	Date Considered	06/19/2011

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. * CITE NO.: Those application(s) which are marked with an single asterisk (*) next to the Cite No. are not supplied (under 37 CFR 1.98(a)(2)(iii)) because that application was filed after June 30, 2003 or is available in the IFW. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.P.S./

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	10/671,435-Conf. #2918
Filing Date	September 24, 2003
First Named Inventor	Robert H. Kelley-Wickemeyer
Art Unit	3643
Examiner Name	R. P. Swiatek
Attorney Docket Number	030048094US

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NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]

Examiner Signature	/Robert P. Swiatek/	Date Considered	06/19/2011

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AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL

This application claims the benefit of U.S. Provisional Application No. 60/028,853, filed Oct. 22, 1996.

FIELD OF THE INVENTION

This invention relates to an aircraft configuration and, more particularly, to a commercial jet aircraft utilizing a slotted cruise airfoil and a wing with very low sweep compared to the sweep of more conventional jet aircraft, achieving the same cruise speed.

BACKGROUND OF THE INVENTION

This invention relates to an aircraft configuration utilizing improved laminar flow. If laminar flow is achieved, aircraft drag, manufacturing costs, and operating costs are substantially reduced. U.S. Pat. No. 4,575,030, entitled, "Laminar Flow Control Airfoil" by L. B. Gratzer, and is assigned to the assignee of this invention. The Gratzer patent provides information on development which includes, among other techniques, suction surfaces and slots to promote natural laminar flow over a main box region of a wing.

SUMMARY OF THE INVENTION

An aspect of the wing of this invention is that it incorporates a slotted cruise airfoil. Slotted cruise airfoil technology that we have developed allows us to produce an unswept, or substantially unswept, wing that achieves the same cruise speed as today's conventional airplanes with higher sweep.

This invention, this technology allows the wing boundary layer to negotiate a strong recovery gradient closer to the wing trailing edge. The result is about a cruise speed of Mach=0.78, but with a straight wing. It also means that for the same lift, the super velocities over the top of the wing can be lower. With very low sweep and this type of cruise pressure distribution, natural laminar flow can easily be obtained. Lower-surface Krueger flaps are installed to increase lift capability for low-speed operation and to protect the wing leading edge from bugs during takeoff and landing to prevent spoiling natural laminar flow.

In another aspect of the invention, heat is transferred from the leading edges of the wing and/or of the main flap to increase the extent of the natural laminar flow.

In still another aspect of this invention, a high wing arrangement allows more freedom for installation of higher bypass ratio engines. An advanced geared fan engine, by-pass ratio 12 or higher, is a possibility that could be easily installed under the high wing. The lower super velocities of the slotted cruise airfoil make the body shock problem associated with many high wing airplanes less of a concern here.

The slotted cruise wing airfoil and the straight wing allow us to modularize the wing and the body so that we can develop a family of airplanes by intermixing different bodies with different wings.

Another aspect of this invention is to reduce costs. The unsweeping of the wing significantly changes the manufacturing processes, reduces manufacturing costs and flow time from detail part fabrication to airplane delivery. The system architecture is all new rather than a major remodeling of a systems architecture from an exiting airplane. It is a top down approach geared towards the requirements of this airplane. Components from existing products will be used whenever they satisfy the requirements of this airplane. The payload systems allow for flexible interiors and extensive use of molded panels.

Still another aspect of this invention is that the expected fuel burn per seat for this type of an airplane is 20% to 30% less than on current jet airplanes, this can be associated with considerable reduction of emission of greenhouse gases.

There is very little difference in ditching capability between a low wing airplane and a high wing airplane. In both cases, the body provides the vast majority of the flotation. The wing provides some stability to prevent the ditched airplane from rolling over.

Another aspect of this invention is that a low wing version with aft mounted engines is also possible. It would feature many, if not most of the above advantages.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. *1a* through *1c* compare the straight wing arrangements with the conventional wing.

FIGS. *2a* through *2c* compare the effect of the straight wing on the configurations with the conventional wing.

FIG. 3 is an isometric view of the high wing version of FIGS. 1 and 2 with a 'T'-tail.

FIG. 4 is an isometric view of the high wing version of FIGS. 1 and 2 with an alternative 'V'-tail empennage arrangement.

FIG. 5 is an isometric view of the low wing version of FIGS. 1 and 2.

FIGS. *6a* and *6b* illustrate the details of the slotted airfoil.

FIGS. *7a* and *7b* compare the pressure distributions for a conventional airfoil and slotted airfoil (*7a* is conventional).

FIG. 8 shows a drag rise comparison between a conventional airfoil and a slotted airfoil.

FIG. 9, the pie-chart illustrates the recurring cost distribution for a conventional wing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The illustrations on FIGS. 1 and 2 serve for the explanation between an existing, prior art airplane configuration as a reference, and two different new arrangements that are the subject of this patent application.

On the prior art reference airplane, FIGS. *1a* and *2a*, a swept wing **1** is attached to the bottom of the fuselage **5**. The basic components of the wing **1** consist of a structural box, which is divided into a left-hand exposed part **2**, a center section **3**, and a right-hand exposed part **4**. Medium bypass ratio engines **6** are attached to struts **7** below the wing. The main landing gear **8** is suspended from the wing **1**. Its support by means of a trunnion requires space within a wing trailing edge extension **9**, also called a 'Yehudi'. Wing leading edge devices **10** are of the common type, slats or Krueger flaps or a combination thereof. Trailing edge devices are flaps **11**, spoilers **12** and ailerons **13**. The length of the main landing gear **8** is determined by engine **6** ground clearance and rotation angle of the airplane. The aft fuselage **5** also shows an 'upsweep' angle **36** for airplane rotation during take-off and landing.

On the 'high wing' example of the invention, FIG. *1b* and *2b*, an unswept wing **14** is attached to the top of the fuselage **15**. Its structural box **16** is a single part, reaching from wing tip to wing tip. It is formed by the rear spar **39**, front spar **82**, upper **83** and lower **84** wing skins. Additional spars in intermediate positions between the rear spar 39 and the front

spar 82 could also be included. High bypass ratio engines 17 are attached to struts 18 below the while. The main landing gear 19 is attached to the fuselage 15, not requiring additional space in the wing platform 14. Wing leading edge devices 20 are Krueger flaps. Spoilers 21 are of the same type as on the reference airplane. However, the flaps 23 represent the 'vane-main' feature with the addition of a slot that is permanent for all flap positions and is a unique key to this invention. More detail is shown on FIG. 6. The slots are extended outboard throughout the ailerons 22. Heat is transferred from the leading edge of the wing 14 and/or of the main flap 23 to increase the extent of natural laminar flow. The Main landing gear 19 is shorter than the gear on the reference airplane. The aft fuselage 15 is more symmetric, ends in a vertical blade shape, and features less upsweep angle 37 and less drag than on the reference airplane due to the features of the 'slotted wing' 14. Compared to a low wing, the high wing 14 allows for a better distribution of the cast Aluminum passenger doors 24, with unobstructed escape slides. The lower deck cargo compartment 25 capacity is also increased because of the absence of the wing box.

On the 'low wing' example of the invention, FIGS. 1*c* and 2*c*, an unswept wing 26 is attached to the bottom of the fuselage 27. Its structural box 28 is a single part, reaching from tip to tip. High bypass ratio engines 29 are attached to struts 30 at both sides of the aft fuselage 27. The main landing gear 31 is attached to the fuselage 27, of requiring additional space in the wing platform 26. Wing leading edge devices 20, spoilers 21 and ailerons 22 are of the same type and shape as on the previous airplane. The flaps 23 represent the 'vane-main' feature with the addition of a slot that is permanent for all flap positions and is a unique key to this invention. More detail is shown on FIG. 6. These are of the same type and shape as on the previous airplane. The slots are also extended outboard throughout the ailerons. Heat is transferred from the leading edge of the wing 26 and/or of the main flap 23 to increase the extent of natural laminar flow. The main landing gear 31 is shorter than the gear on the reference airplane. The aft fuselage 27 is more symmetric, ends in a vertical blade shape, and features less upsweep angle 38 and less drag than on the reference airplane due to the features of the 'slotted wing' 26. Basically, the shape and size of the wing 26 and the fuselage 27 are similar to the airplane in FIGS. 1*b* and 2*b*.

The embodiments of the whole airplane configurations are shown on FIGS. 3 through 5. All three figures represent examples of this invention.

FIG. 3 is an isometric view of the high wing version, FIGS. 1*b* and 2*b*. The empennage arrangement resembles a 'T'-tail 32. The nose landing gear 33 is shorter than on the Reference airplane, because of the close ground proximity.

FIG. 4 is another isometric view of the high wing 14 version, FIGS. 1*b* and 2*b* with an alternative empennage arrangement. The 'T'-tail arrangement of FIG. 3 has been replaced by a 'V'-shape 34.

FIG. 5 is an isometric view of the low wing 26 version, FIGS. 1*c* and 2*c*. The nose landing gear 35 is shorter than on the reference airplane, because of the close ground proximity.

FIG. 6 is extracted from the concurrent patent application Ser. No. 08/735,233, filed Oct. 22, 1996 entitled, "Slotted Cruise Trailing Edge Flap" by G. L. Siers. The two views, FIG. 6*a* and 6*b* illustrate the two extreme positions of the trailing edge flap.

Of particular interest is the wing rear spar 39 shown in combination with the rear fragment of a wing 14 or 26. The components of the flap 23 are generally located aft of, and are structurally supported by, the wing rear spar 39.

In general, a slotted cruise trailing edge flap 23 formed in accordance with the application Ser. No. 08/735,233 has a single-slotted configuration during cruise, FIG. 6*a* and a double-slotted configuration during takeoff(not shown) and landing, FIG. 6*b*. This is accomplished by a flap assembly 23 that is movable between a stowed position and an extended position. In the stowed position a single slot is present, and in the extended position two slots are present. More specifically, flap assembly 23 includes two airfoil elements, a vane element and a main element, that are arranged in fixed relation to one another. The space between the airfoil elements forms a permanent single slot. At various support locations along the wing trailing edge, the flap assembly 23 is movably connected to an extension assembly 40 that is secured to the wing rear spar 39.

The extension assembly 40 includes a support structure to which the flap assembly 23 is translatable and rotatably connected. The extension assembly 40 further includes an actuation mechanism that moves the flap assembly 23 relative to the support structure. In a stowed position, the vane element of flap 23 nests into the wing 14 or 26 such that the permanent single slot remains available to direct airflow from regions below the wing to regions above the wing. In an extended position, the vane and main elements of flap 23 form a double-slotted arrangement by rotating downward and translating rearward relative to the wing 14 or 26.

Physical factors limiting the performance of transonic cruise airfoils

In the following discussion, "airfoil" refers to the cross-sectional shape of a wing in planes that are substantially longitudinal and vertical, which plays a major role in determining the aerodynamic performance of said wing. "Transonic cruise" refers to operation of the wing at high subsonic speed such that the airflow past the wing contains local regions of supersonic flow. "Mach number" refers to the ratio of the flow speed to the speed of sound.

The performance of an airfoil in transonic cruise applications can be characterized by four basic measures:

1) The airfoil thickness, usually expressed as the maximum-thickness ratio (maximum thickness divided by chord length). Thickness is beneficial because it provides the room needed for fuel and mechanical systems and because a wing structure with greater depth can be lighter for the same strength.
2) The speed or Mach number at the preferred operating condition The Mach number capability of the airfoil, modified by a factor related to the sweep angle of the wing, contributes directly to the cruise speed of the airplane.
3) The lift coefficient at the preferred operating condition. Increased lift coefficient is advantageous because it could allow increased weight (e.g. more fuel for longer range) or a higher cruise altitude.
4) The drag coefficient at the preferred operating condition and at other operating conditions that would be encountered in the mission of an airplane. Reducing the drag reduces fuel consumption and increases range.

Other measures such as the pitching-moment characteristics and the lift capability at low Mach numbers are also significant, but are less important than the basic four.

Together, the four basic performance measures define a level of performance that is often referred to as the "technology level" of an airfoil. The four basic performance measures impose conflicting requirements on the designer in

the sense that design changes intended to improve one of the measures tend to penalize at least one of the other three. A good design therefore requires finding a favorable compromise between the four measures.

At any given technology level, it is generally possible to design a wide range of individual airfoils tailored to different preferred operating conditions and representing different trade-offs between the four basic performance measures. For example, one airfoil could have a higher operating Mach number than another, but at the expense of lower lift and higher drag. Given modern computational fluid dynamics tools, designing different airfoils at a given technology level is generally a straightforward task for a competent designer. On the other hand, improving the technology level, say by improving one of the basic performance measures without penalizing any of the other three, tends to be more difficult, and the more advanced the technology level one starts with, the more difficult the task becomes. Starting with an airfoil that is at a technology level representative of the current state of the art, it can be extremely difficult to find significant improvements.

The main factors that limit performance are associated with the physics of the flow over the upper surface of the airfoil. To understand these factors, it helps to look at a typical transonic cruise airfoil pressure distribution, plotted in terms of the pressure coefficient C_P on a negative scale, as shown in FIG. 7(*a*). For reference, the shape of the airfoil is shown just below the pressure-distribution plot. On the C_P scale shown, C_P=0 is the static pressure of the freestream flow far from the airfoil, which is assumed to be at a subsonic speed. At each point on the surface, the value of C_P, in addition to defining the pressure, corresponds to a particular value of the floss velocity just outside the thin viscous boundary layer on the surface. Negative C_P (above the horizontal axis) represents lower pressure and higher velocity than the freestream. while positive C_P (below the horizontal axis) corresponds to higher pressure and lower velocity. A particular level of negative C_P corresponds to sonic velocity and is shown by the dotted line **41**.

The lower curve **42** on the pressure-distribution plot represents the pressure on the lower surface **43**, or high-pressure side, and the upper curve **44** represents pressure on the upper-surface **45**. The vertical distance between the two curves indicates the pressure difference between the upper and lower surfaces, and the area between the two curves is proportional to the total lift generated by the airfoil. Note that near the leading edge there is a highly positive spike in the C_P distribution **46** at what is called the "stagnation point" **47**, where the oncoming flow first "attaches" to the airfoil surface, and the flow velocity outside the boundary layer is zero. Also, note that the upper- and lower-surface C_P distributions come together at the trailing edge **48**, defining a single value of C_P **49** that is almost always slightly positive. This level of C_P at the trailing edge, as will be seen later, has an important impact on the flow physics. Because the trailing-edge C_P is dictated primarily by the overall airfoil thickness distribution, and the thickness is generally constrained by a number of structural and aerodynamic factors, trailing-edge C_P is something over which the designer has relatively little control. Away from the leading-edge stagnation point and the trailing edge, the designer, by varying the airfoil shape, has much more control over the pressure distribution.

For a given airfoil thickness and Mach number, the problem of achieving a high technology level boils down to the problem of maximizing the lift consistent with a low drag level. Increasing the lift solely by increasing the lower-surface pressure is generally not possible without reducing airfoil thickness. Thus the designer's task is to reduce the upper-surface pressure so as to produce as much lift as possible, but to do so without causing a large increase in drag. In this regard, the pressure distribution shown in FIG. (7*a*) is typical of advanced design practice. The operating condition shown is close to the preferred operating condition that might be used for the early cruise portion of an airplane mission. The drag at this condition is reasonably low, but at higher Mach numbers and/or lift coefficients, the drag would increase rapidly.

Note that the upper-surface C_P **44** over the front half of the airfoil is above the dotted line **41**, indicating that the flow there is mildly supersonic. Just aft of midchord, this supersonic zone is terminated by a weak shock, indicated on the surface as a sudden increase in C_P **50** to a value characteristic of subsonic flow. The C_P distribution in the supersonic zone **51** is deliberately made almost flat, with only an extremely gradual pressure rise, in order to keep the shock from becoming stronger and causing increased drag at other operating conditions. The shock is followed by a gradual pressure increase **52**, referred to as a "pressure recovery", to a slightly-positive C_P **49** at the trailing edge. The location of the shock and the pressure distribution in the recovery region are carefully tailored to strike a balance between increased lift and increased drag.

Trying to increase the lift will tend to move the airfoil away from this favorable balance and increase the drag. For example, one way of adding lift would be to move the shock **50** aft. This, however, would require a steeper recovery (because the immediate post-shock C_P and the trailing-edge C_P are both essentially fixed), which would cause the viscous boundary layer to grow thicker or even to separate from the surface, either of which would result in a significant drag increase. The other obvious way to increase lift would be to lower the pressure ahead of the shock even further (move the C_P curve **51** upward over the forward part of the airfoil and increase the supersonic flow velocity there), but this would increase the pressure jump across the shock, which would result in an increase in the so-called shock drag. For single-element transonic airfoils at the current state of the art, this compromise between lift and drag has reached a high level of refinement, and it is unlikely that any large improvement in technology level remains to be made.

Potential technology advantage of the slotted airfoil

The shape and resulting pressure distribution of a slotted transonic cruise airfoil are shown in FIG. (6) and (7*b*). The airfoil **23** consists of two elements (a forward element **60** and an aft element **61**) separated by a curved channel (**62**, the slot) through which air generally flows from the lower surface **84** to the upper surface **64**. In this example, the slot lip (**65**, the trailing edge of the forward element) is just aft of 80 percent of the overall chord from the leading edge, and the overlap of the elements is about 3 percent of the overall chord. Pressure distributions are shown for both elements, so that the pressure distributions overlap where the airfoil elements overlap. As with the conventional airfoil, the upper curves **66**,**67** give the C_P distributions on the upper surfaces **64**,**83**, and the lower curves **68**,**69** give C_P on the lower surfaces **84**,**70**. Note that there are two stagnation points **71**,**72** and their corresponding high-pressure spikes **73**,**74**, one on each element, where the oncoming flow attaches to the surface near each of the leading edges.

To begin the consideration of the flow physics, note that the preferred operating condition for the slotted airfoil shown is faster than that of the single-element airfoil (Mach 0.78 compared with 0.75), and that the lift coefficient is

slightly higher, while both airfoils have the same effective thickness for structural purposes. At the slotted airfoil's operating condition, any single-element airfoil of the same thickness would have extremely high drag. The slotted airfoil's substantial advantage in technology level results from the fact that the final pressure recovery 75 is extremely far aft, beginning with a weak shock 76 at about 90 percent of the overall chord. Such a pressure distribution would be impossible on a single-element airfoil because boundary-layer separation would surely occur, preventing the shock from moving that far aft. The mechanism, loosely termed the "slot effect", by which the slot prevents boundary-layer separation, combines several contributing factors:

1) The boundary layer on the upper surface 83 of the forward element is subjected to a weak shock 77 at the slot lip 65, but there is no post-shock pressure recovery on the forward element. This is possible because the aft element 61 induces an elevated "dumping velocity" at the trailing edge of the forward element (The trailing-edge C_p 78 on the forward element is strongly negative, where on a single-element airfoil the trailing-edge C_p is generally positive).
2) The upper- and lower-surface boundary layers on the forward element combine at the trailing edge 65 to form a wake that flows above the upper surface 64 of the aft element and that remains effectively distinct from the boundary layer that forms on the upper surface of the aft element. Over the of part of the aft element, this wake is subjected to a strong pressure rise 75,76, but vigorous turbulent mixing makes the wake very resistant to flow reversal.
3) The boundary layer on the upper surface 64 of the aft element has only a short distance over which to grow, starting at the stagnation point 72 near the leading edge of the aft element, so it is very thin when it encounters the final weak shock 76 and pressure recovery 75, and is able to remain attached. With regard to its pressure distribution and boundary-layer development, the aft element is, in effect, a separate airfoil in its own right, with a weak shock and pressure recovery beginning at about the mid-point of its own chord, for which we would expect attached flow to be possible.

The upper-surface pressure distribution of FIG. 7(*b*) is a relatively extreme example of what the slot effect makes possible. A range of less-extreme pressure distributions intermediate between that shown in FIG. 7(*b*) and the single-element pressure distribution of FIG. 7(*a*) can also take advantage of the slot effect. The shock on the forward element does not have to be all the way back at the slot lip, and there does not have to be a supersonic zone on the upper surface of the aft element. In fact, the airfoil of FIG. 7(*b*) displays a sequence of such intermediate pressure distributions when operating at lower Mach numbers and lift coefficients than the condition shown. The slot effect is still needed to prevent flow separation at these other conditions.

One way of comparing the technology levels of airfoils is to plot the drag-rise curves (drag coefficient versus Mach number at constant lift coefficient), as shown in FIG. (8). Here the dashed curve 80 is for the single-element airfoil of FIG. 7(*a*) at a lift coefficient Cl of 0.75, and the solid curve 81 is for the slotted airfoil of FIG. 7(*b*) at a slightly higher Cl of 0.76. It is clear that the low-drag operating range of the slotted airfoil extends up to 0.03 Mach faster than the single-element airfoil, with slightly higher lift and the same thickness. Of course the slotted airfoil could be redesigned to use this technology advantage for purposes other than higher speed, for example, to achieve even higher lift at the same speed as the single-element airfoil.

The pressure distribution on the lower surface also contributes to the technology level of the slotted airfoil of FIG. 7(*b*). Compare the pressure distribution 68 on the lower surface 84 of the forward element of the slotted airfoil with the corresponding pressure distribution 42 on the lower surface 43 of the single-element airfoil of FIG. 7(*a*). The flatter pressure distribution on the slotted airfoil results in less curvature of the lower surface of the airfoil and greater depth of the airfoil at the locations where the front and rear spars of the main structural box would be placed (typically about 15 percent and 64 percent of the overall chord). Flatter lower-surface skins and deeper spars are both favorable to the structural effectiveness of the main box structure. In the design of the airfoil of FIG. 7(*b*) this advantage was traded so as to contribute to the improved Mach number and lift coefficient, while keeping the structural effectiveness (bending strength) of the wing box the same as that of the single-element airfoil of FIG. 7(*a*).

The unsweeping of the wing significantly changes the manufacturing processes, reduces manufacturing costs and flow time from detail part fabrication to airplane delivery. Conventional commercial jet airplane wings are built with structural splices where the stringers and spars change direction, generally at the side of body. With an unswept wing, one of the spars has no changes in direction and no splice. Wing box structural stringers (skin panel stiffeners) are parallel to the straight spar and do not have splices. As with the spar and stringers, the wing structural skin does not require spanwise splicing although chord wise splicing will be used when the limits of raw material make single piece wing skins impractical. Building the wing as a single piece rather than a left wing a right wing and a wing stub eliminates the parts associated with splicing and the labor and flow time required to join the left and right wing to the wing stub. Significant reductions in the quantity of parts and manufacturing labor are a result of unsweeping the wing. FIG. 9 represents conventional wing recurring costs, the outboard wing cost represented by 91 will be reduced by 30%. This savings is the combination of eliminating the wing joints, and the reduction of wing shear and dihedral. Another 12% cost reduction could be realized with low cost graphite construction. The wing stub cost represented by 92 will be reduced by 90% because it is not required.

Unsweeping the wing 14 changes the wing relationship with the main landing gear 19. Conventional swept wing commercial jet airplanes integrate the landing gear into the portion of the wing aft of the rear spar 9. With the unswept high wing commercial jetliner configuration shown in FIGS. 1 through 5, the landing gear 19 is not integrated into the wing at all, reducing the plan area of the wing and simplifying the wing aft of the rear spar 9. The cost reduction is relative to FIG. 9, the recurring cost of the fixed trailing edge (the non-moving parts of the wing aft of the rear spar) represented by 93 is reduced by 25%. One disadvantage of reducing the area of the fixed trailing edge is the reduction in wing thickness at the rear spar 39. This may result in a requirement for a mid spar or spars with more depth. The spoilers 21, fixed leading edge, moveable leading edge 20 and moveable trailing edge 23 costs represented by 94 are not expected to change. The additional cost associated with designing the slot 62 into the airfoil is expected to be offset by the elimination of an inboard aileron and the simplification of the high lift system.

Structural design advantages of the unswept wing include higher loading of the front spar 82 and thereby unloading the rear spar 39 and aft part of the wing skins 83 and 84. This load redistribution results in the ability to increase the

structural aspect ratio of the wing while maintaining the same stress levels. Utilizing a mid spar or spars may increase the wing aspect ratio further with out increasing stress levels.

The slotted cruise wing airfoil and the straight wing allow us to modularize the wing 14 and the body 15, so that we can develop a family of airplanes by intermixing different bodies with different wings.

Aspect Ratio is the ratio of $(span)^2$ divided by wing area. Structural Aspect Ratio is the ratio of $(structural\ span)^2$ divided by structural wing area.

While preferred embodiments of the invention have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A commercial jetplane capable of flying at a cruise speed of Mach=0.78 or above, comprising:

a fuselage;

a landing gear mounted on said fuselage;

a single wing attached to said fuselage, said single wing being substantially unswept with a high aspect ratio, and including:

a forward airfoil element having an upper surface and a lower surface;

an aft airfoil element having an upper surface and a lower surface;

an internal structure comprising at least two spars extending from one tip to an opposing tip of said single wing, with a rear one of the spars being straight and unswept in plan view;

an airfoil structure having a slot that allows airflow from the forward airfoil element to the aft airfoil element, wherein during cruising flight of the airplane, said airfoil structure having said slot diverts some of the air flowing along the lower surface of the forward airfoil element to flow over the upper surface of the aft airfoil element, and where the lower surface of the forward airfoil element and the lower surface of the aft airfoil element are shaped to provide an efficient cross section for a main structural box of the single wing; and

said wing and said fuselage being constructed of at least one of aluminum and graphite composite.

2. The airplane of claim 1 wherein said airfoil structure having a slot produces natural laminar flow over the aft airfoil element of said single wing.

3. The airplane of claim 1 wherein said airfoil structure having said slot produces natural laminar flow over the forward airfoil element of said single wing.

4. The airplane of claim 1 wherein heat is transferred from a leading edge of at least one of said wing and main flap to increase the extent of said natural laminar flow.

5. An airplane of claim 1 which comprises a "T"-tail type empennage.

6. The airplane of claim 1 which comprises a "V"-tail type empennage.

7. The airplane of claim 1 which comprises a low tail type empennage.

8. The airplane of claim 7, wherein at least two high bypass ratio engines are attached to the airframe.

9. The airplane of claim 8 wherein said high bypass engines are geared fan engines or unducted fans which are energy efficient with reduced fuel consumption, noise and greenhouse gas emissions.

10. The airplane of claim 1 wherein the reduced rotation angle also decreases the aft body upsweep and reduces drag.

11. An airplane of claim 1 wherein said single wing is attached to the top of said fuselage and the engines are attached below the wing.

12. An airplane of claim 1 wherein said single wing is attached to the bottom of said fuselage and said engines are attached to the aft end of the fuselage.

* * * * *

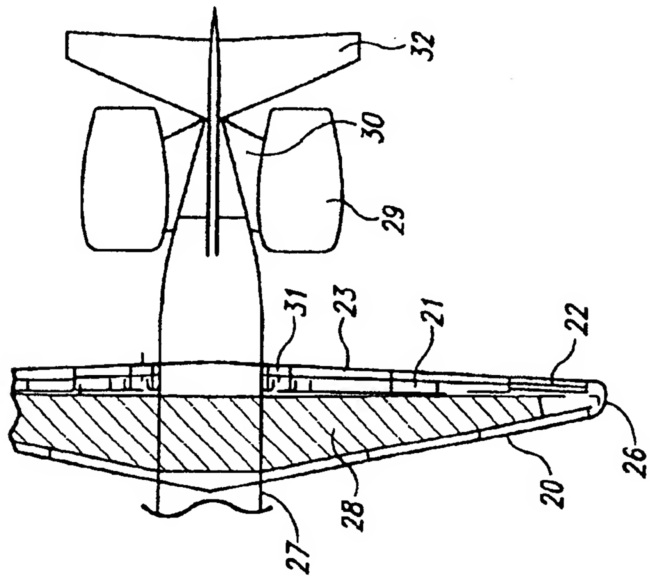


Fig. 1C

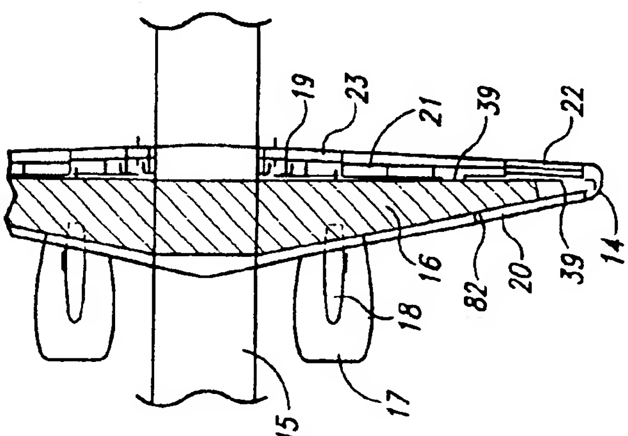


Fig. 1B

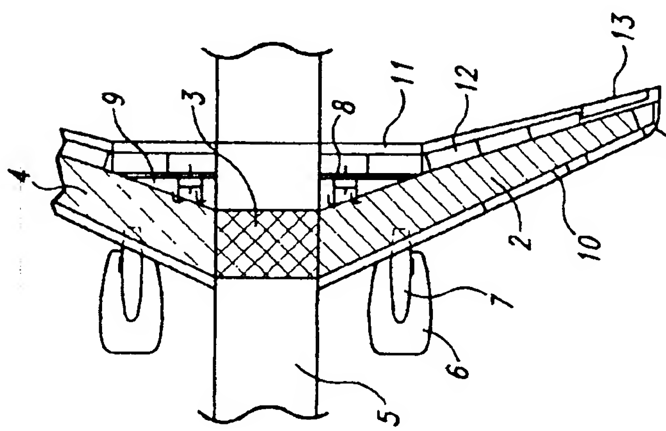


Fig. 1A (Prior Art)

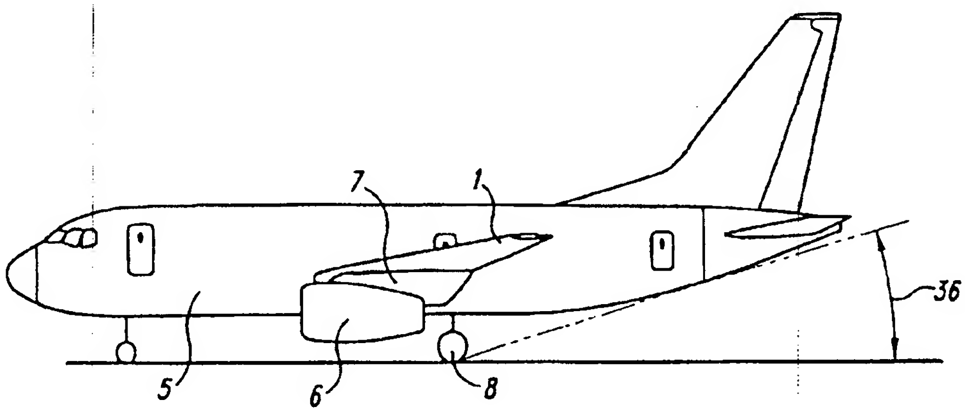


Fig. 2A
(Prior Art)

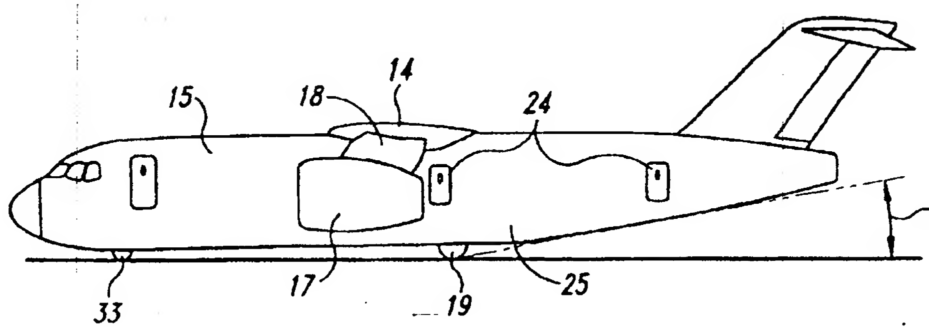


Fig. 2B

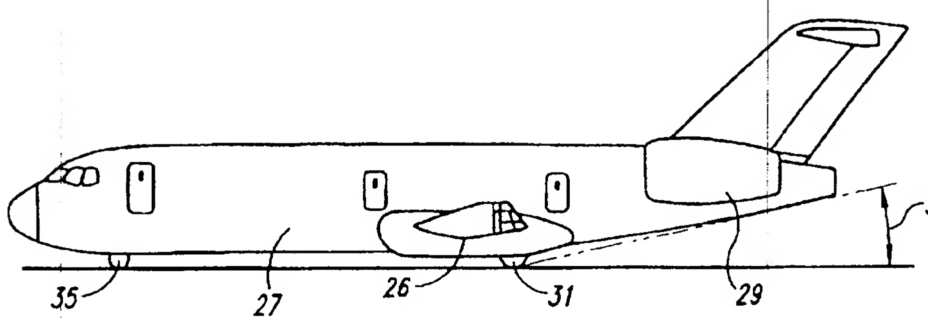


Fig. 2C

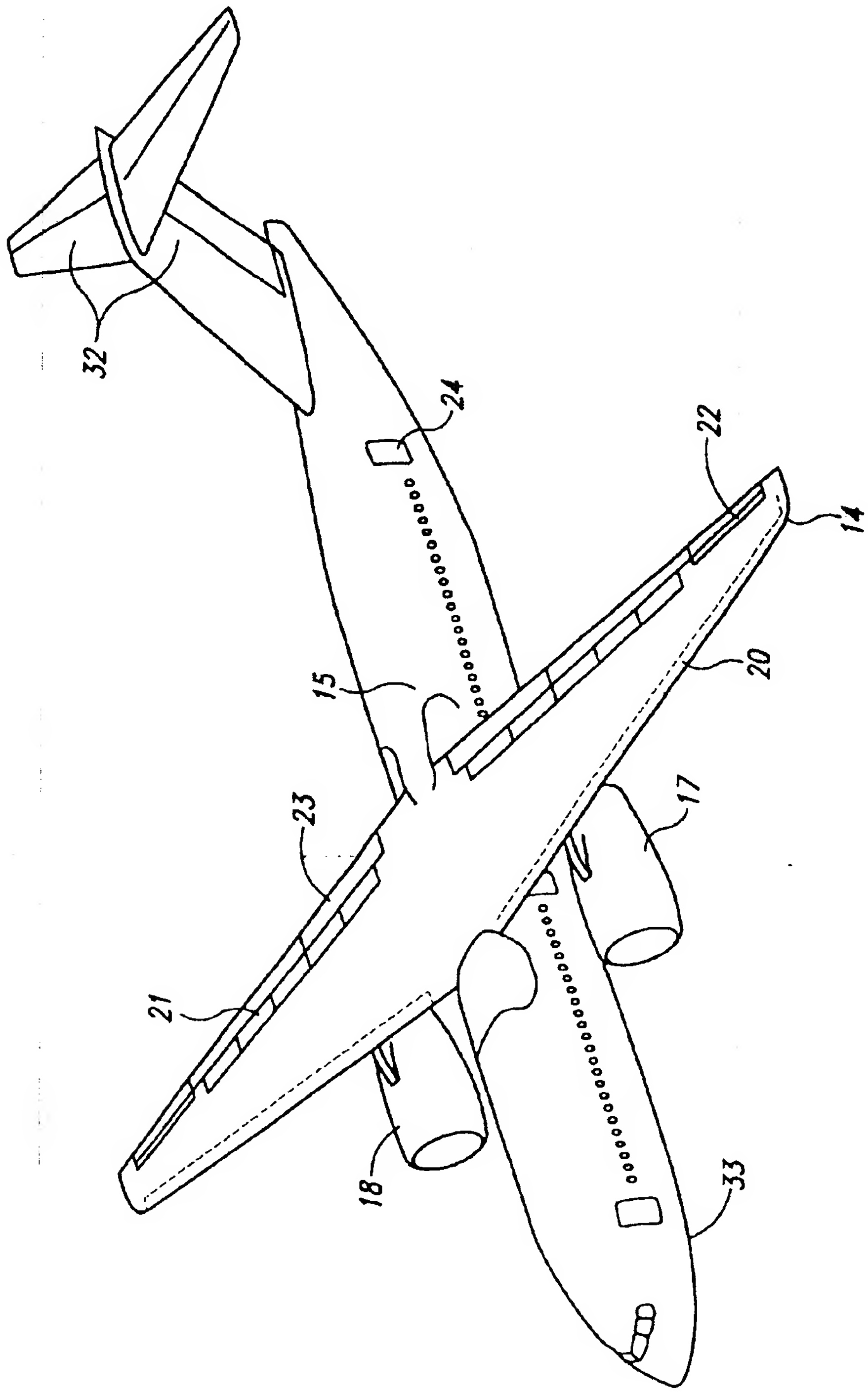


Fig. 3

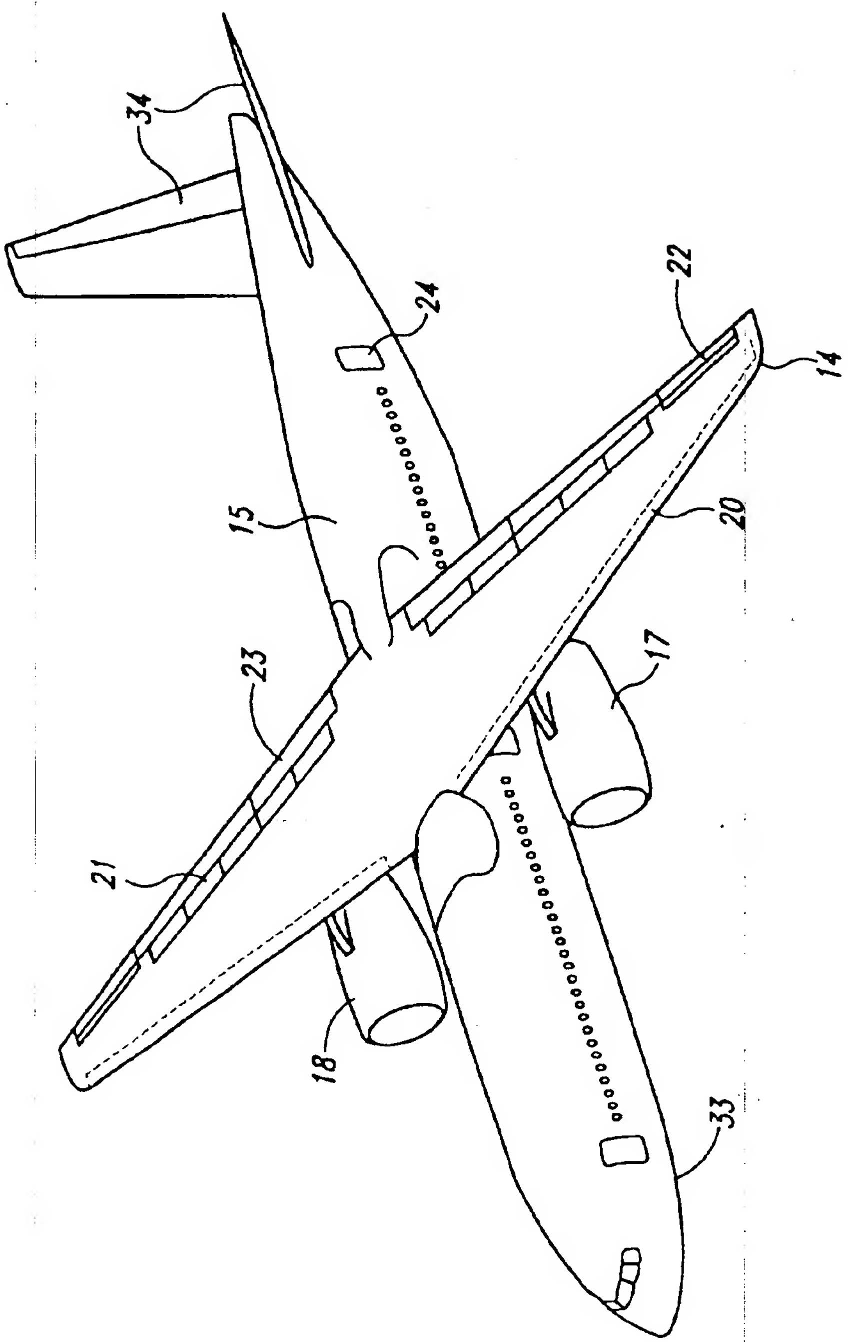


Fig. 4

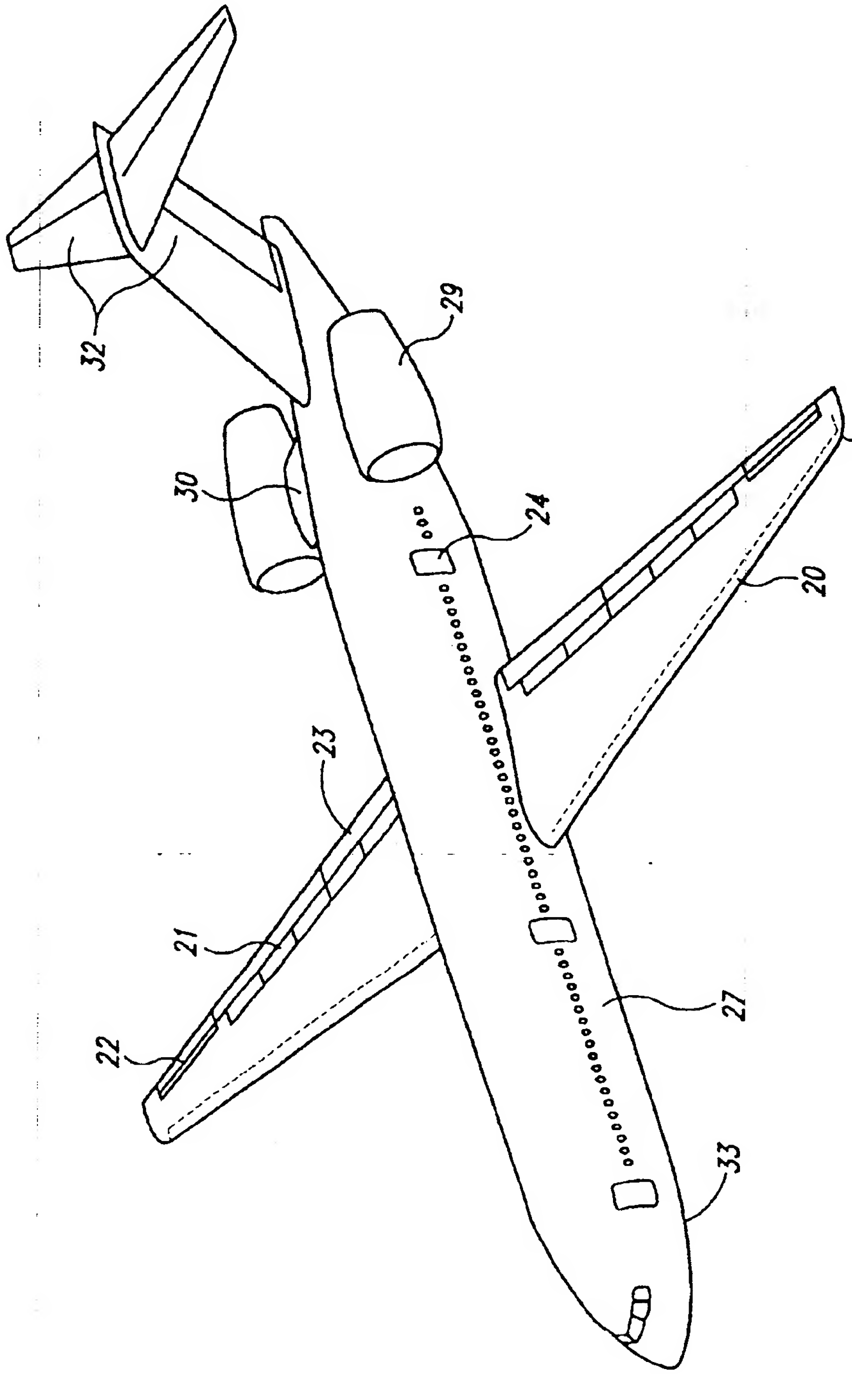


Fig. 5

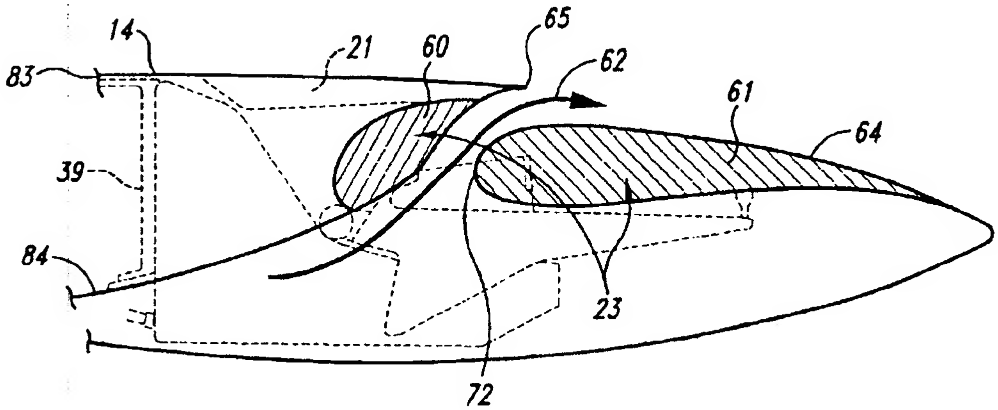


Fig. 6A

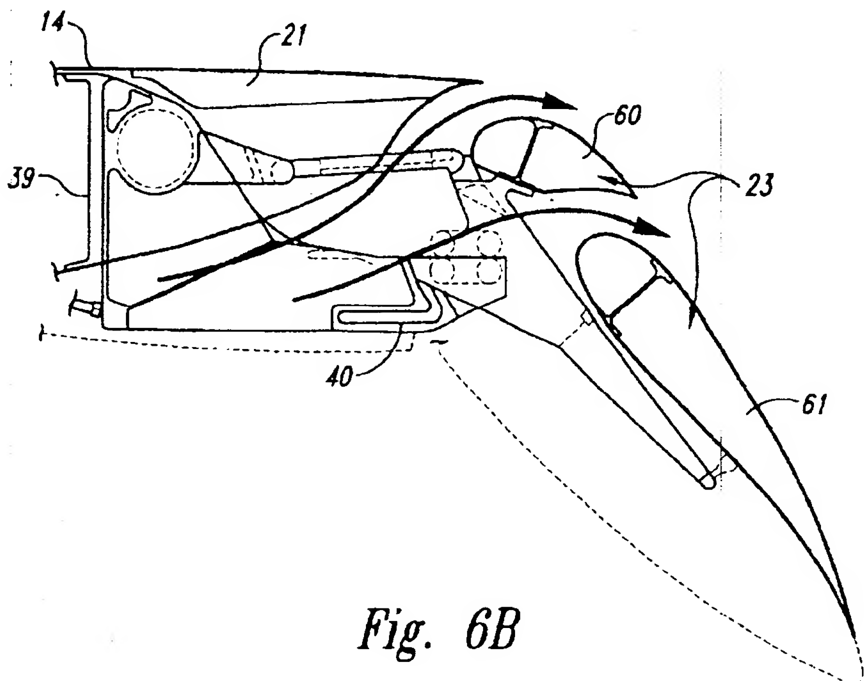
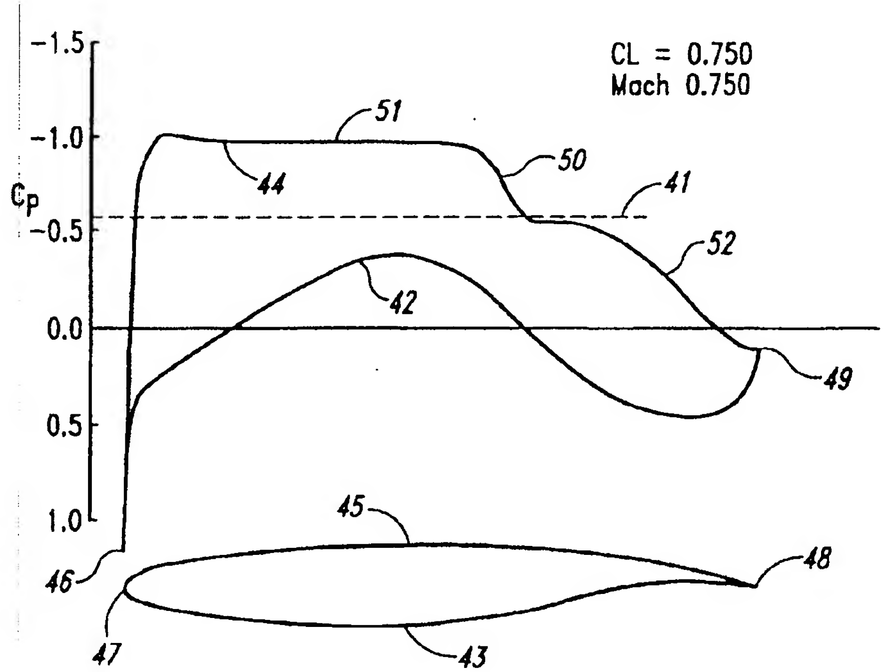


Fig. 6B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43

Fig. 7A

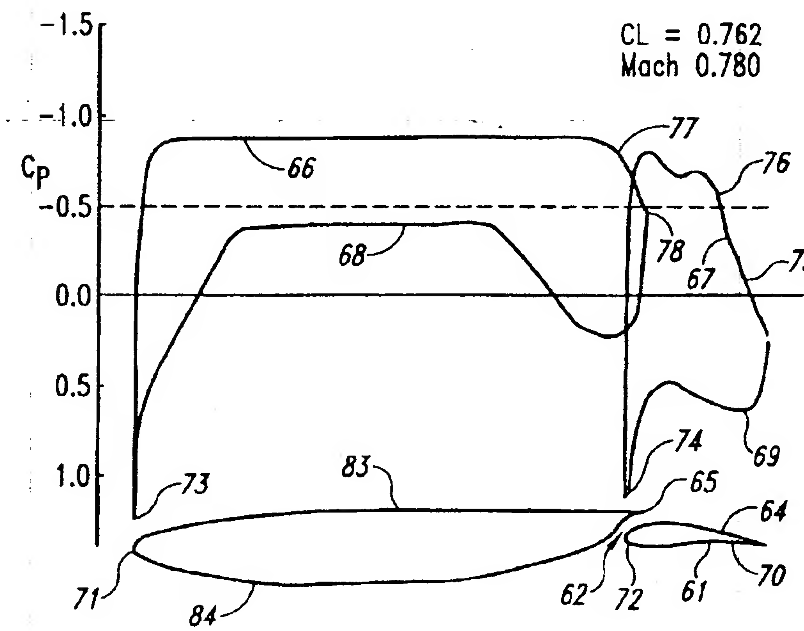
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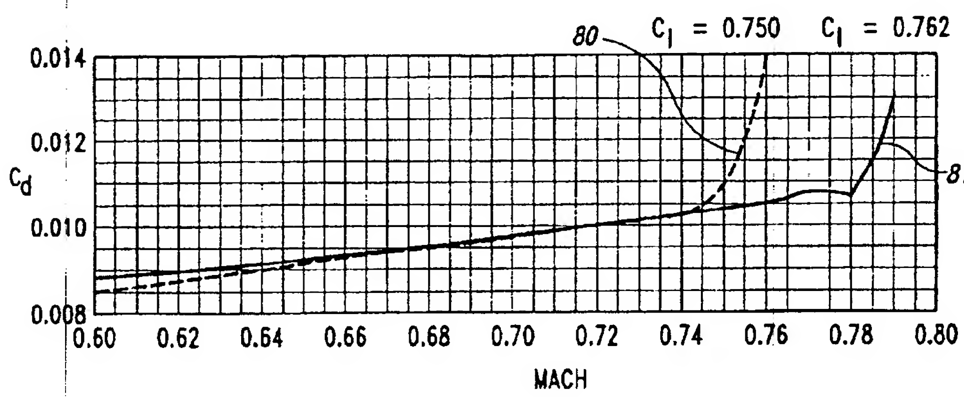
Fig. 7B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MACH

Fig. 8

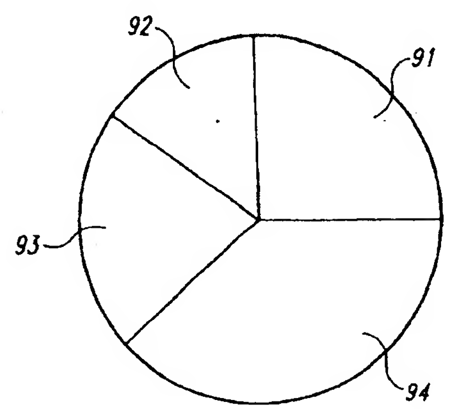

92
91
93
94

Fig. 9

EXHIBIT B

Copy of signed Domestic Return Receipt by James McLean

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

James Douglas McLean
7004 South 130th Street
Seattle, WA 98178-4218

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X James McLean
☐ Agent
☐ Addressee

B. Received by (*Printed Name*) James McLean

C. Date of Delivery 10-15-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (*Extra Fee*) ☐ Yes

2. Article Number
(*Transfer from service label*) 7004 2890 0000 2852 1994

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

UNITED STATES POSTAL SERVICE

SEATTLE WA 981
15 OCT 2011 PM 7 T

First-Class Mail
Postage & Fees Paid
USPS
Permit No. G-10

• Sender: Please print your name, address, and ZIP+4 in this box •

Perkins Coie
Attn: Paula Quinanola
1201 Third Avenue, Ste. 4800
Seattle, WA 98101

EXHIBIT C

Letter sent to James Douglas McLean on November 10, 2011, and attachments

Perkins Coie

1201 Third Avenue, Suite 4800
Seattle, WA 98101-3099
PHONE: 206.359.8000
FAX: 206.359.9000
www.perkinscoie.com

Paula M. Quinanola
PHONE: (206) 359-3093
EMAIL: PQuinanola@perkinscoie.com

November 10, 2011

CERTIFIED MAIL

James Douglas McLean
7004 South 130th Street
Seattle, WA 98178-4718

Re: U.S. Patent Application No. 10/671,435
Title: AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL
Boeing Reference No. 96-273B
Perkins Reference No. 03004.8094US00

Dear James:

On September 24, 2003 we filed a reissue application of issued U.S. Patent 6,293,497.

Per my October 14, 2011 correspondence, we received an Office Action for the above-referenced reissue application. I've enclosed a copy of the Office Action for your reference.

In order to respond to the Office Action, we will need an executed Supplemental Declaration from each of the inventors. Please sign and return the attached Declaration document to us by November 29, 2011.

Please find enclosed a copy of the pending claims and a copy of U.S. Patent 6,293,497.

If you have any questions, please do not hesitate to contact us.

Best Regards,

Paula M. Quinanola
Paralegal

PMQ::pq

Enclosures:

- Supplemental Declaration
- Copy of Non-Final Office Action
- Copy of U.S. Patent 6,293,497
- Copy of the Pending Claims

PTO/SB/51S (09-07)
Approved for use through 08/31/2013. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

SUPPLEMENTAL DECLARATION FOR REISSUE PATENT APPLICATION TO CORRECT "ERRORS" STATEMENT (37 CFR 1.175)

Attorney Docket Number	030048094US
First Named Inventor	Robert H. Kelley-Wickemeyer
COMPLETE if known	
Application Number	10/671,435-Conf. #2918
Filing Date	September 24, 2003
Art Unit	3643
Examiner Name	R. P. Swiatek

I/We hereby declare that:

Every error in the patent which was corrected in the present reissue application, and is not covered by a prior oath/declaration submitted in this application, arose without any deceptive intention on the part of the applicant.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

I/We hereby declare that all statements made herein of my/our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname	
Robert H.		Kelley-Wickemeyer	
Inventor's Signature		Date	
Name of Second Inventor:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])		Family Name or Surname	
Gerhard E.		Seidel	
Inventor's Signature		Date	

☒ Additional inventors or legal representative(s) are being named on the 1 supplemental sheet(s) PTO/SB/02A or 02LR attached hereto.

PTO/SB/02A (07-07)
Approved for use through 09/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION	ADDITIONAL INVENTOR(S) Supplemental Sheet Page 1 of 1

Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any)): Peter Z.		Family Name or Surname: Anast	
Inventor's Signature			Date
Residence: City: Bellingham	State: WA	Country: United States of America	Citizenship: US
Mailing Address: 1323 Varsity Place			
City: Bellingham	State: WA	Zip: 98225	Country: United States of America
Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any)): James Douglas		Family Name or Surname: McLean	
Inventor's Signature			Date
Residence: City	State	Country	Citizenship: US
Mailing Address: 7004 South 130th Street			
City: Seattle	State: WA	Zip: 98178	Country: United States of America
Name of Additional Joint Inventor, if any:		☐ A petition has been filed for this unsigned inventor	
Given Name (first and middle (if any))		Family Name or Surname	
Inventor's Signature			Date
Residence: City	State	Country	Citizenship
Mailing Address:			
City	State	Zip	Country

Copy of Non-Final Office Action for U.S. Application No. 10/671,435

03004-8094.US00

JMW/PQ

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/671,435	09/24/2003	Robert H. Kelley-Wickemeyer	03004.8094US	2918

64066 7590 06/29/2011

PERKINS COIE LLP (BOEING)
P.O. BOX 1247
PATENT - SEA
SEATTLE, WA 98111-1247

REVIEWED
By Sam Beard at 9:02 am, Jun 29, 2011

Docketed:
3mo Due Date - 09/29/11
6mo Deadline - 12/29/11

EXAMINER	
SWIATEK, ROBERT P	
ART UNIT	**PAPER NUMBER**
3643	
NOTIFICATION DATE	**DELIVERY MODE**
06/29/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patentprocurement@perkinscoie.com

Office Action Summary	Application No.	Applicant(s)	
	10/671,435	KELLEY-WICKEMEYER ET AL.	
	Examiner	Art Unit	
	Rob Swiatek	3643	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01 June 2011*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-37,39-48 and 50-78* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-37,39-48 and 50-78* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☒ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *6-19-09; 5-14-11; 6-1-11*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

The reissue declaration filed with this application is defective (see 37 CFR 1.175 and MPEP § 1414) because of the following: It does not state that applicant (1) believes the original patent to be partly inoperative or invalid by reason of the patentee claiming more than patentee had a right to claim in the patent *or* (2) believes the original patent to be partly inoperative or invalid by reason of the patentee claiming less than patentee had a right to claim in the patent. Where, however, a given independent claim is considered to be overly broad, and another independent claim is considered to be overly narrow, patentee has claimed both more *and* less than patentee had a right to claim. In this latter instance, both above-quoted statements would be used. Applicant's statement that the original patent is "wholly or partly inoperative or invalid . . . . by reason of the patentee claiming more or less than he had the right to claim in the patent" is improper because a claim cannot claim "more *or* less" at the same time.

In accordance with 37 CFR 1.175(b)(1), a supplemental reissue oath/declaration under 37 CFR 1.175(b)(1) must be received before this reissue application can be allowed.

Claims 1-37, 39-48, 50-78 are rejected as being based upon a defective reissue declaration under 35 U.S.C. 251. See 37 CFR 1.175. The nature of the defects is set forth above.

Receipt of an appropriate supplemental oath/declaration under 37 CFR 1.175(b)(1) that includes the "Every error . . . " language set forth below as well as language addressing statements (1) and (2) above will overcome this rejection under 35 U.S.C. 251. An example of acceptable language to be used in the supplemental oath/declaration is as follows:

> "Every error in the patent which was corrected in the present reissue application, and is not covered by a prior oath/declaration submitted in this application, arose without any deceptive intention on the part of the applicant."

See MPEP § 1414.01.

If the above rejection is overcome, claims 1-37, 39-48, 50-78 will be allowed.

/Rob Swiatek/

Primary Examiner, Art Unit 3643

Ph.: 571/272-6894
19 June 2011

Copy of the Pending Claims
U.S. Application No. 10/671,435

PENDING CLAIMS
Reissue U.S. Application No. 10/671,435
03004.8094US

1. A commercial jetplane capable of flying at a cruise speed of Mach=0.78 or above, comprising:

a fuselage;

a landing gear mounted on said fuselage;

a single wing attached to said fuselage, said single wing being substantially unswept with a high aspect ratio, and including:

a forward airfoil element having an upper surface and a lower surface;

an aft airfoil element having an upper surface and a lower surface;

an internal structure comprising at least two spars extending from one tip to an opposing tip of said single wing, with a rear one of the spars being straight and unswept in plan view;

an airfoil structure having a slot that allows airflow from the forward airfoil element to the aft airfoil element, wherein during cruising flight of the airplane, said airfoil structure having said slot diverts some of the air flowing along the lower surface of the forward airfoil element to flow over the upper surface of the aft airfoil element, and where the lower surface of the forward airfoil element and the lower surface of the aft airfoil element are shaped to provide an efficient cross section for a main structural box of the single wing; and

said wing and said fuselage being constructed of at least one of aluminum and graphite composite.

2. The airplane of claim 1 wherein said airfoil structure having a slot produces natural laminar flow over the aft airfoil element of said single wing.

3. The airplane of claim 1 wherein said airfoil structure having said slot produces natural laminar flow over the forward airfoil element of said single wing.

4. The airplane of claim 1 wherein heat is transferred from a leading edge of at least one of said wing and main flap to increase the extent of said natural laminar flow.

5. An airplane of claim 1 which comprises a "T"-tail type empennage.

6. The airplane of claim 1 which comprises a "V"-tail type empennage.

7. The airplane of claim 1 which comprises a low tail type empennage.

8. The airplane of claim 7, wherein at least two high bypass ratio engines are attached to the airframe.

9. The airplane of claim 8 wherein said high bypass engines are geared fan engines or unducted fans which are energy efficient with reduced fuel consumption, noise and greenhouse gas emissions.

10. The airplane of claim 1 wherein the reduced rotation angle also decreases the aft body upsweep and reduces drag.

11. An airplane of claim 1 wherein said single wing is attached to the top of said fuselage and the engines are attached below the wing.

12. An airplane of claim 1 wherein said single wing is attached to the bottom of said fuselage and said engines are attached to the aft end of the fuselage.

13. An aircraft, comprising:

a fuselage,

at least one wing attached to the fuselage, the wing having an upper surface, a lower surface, and an internal structure including at least one spar;

a trailing edge device carried by the wing, the trailing edge device having an upper surface and a lower surface, the upper surface of the trailing edge device being recessed away from an aft-extended contour of the wing upper surface in a thickness direction along its entire length when in a neutral, undeflected, undeployed position, at least one of the at least one wing and the trailing edge device having a spanwise slot that allows airflow from the at least one wing to the trailing edge device, the slot having an aft-facing exit opening at an offset between the upper surfaces of the at least one wing and the trailing edge device, the offset being in the thickness direction, wherein during cruising flight of the aircraft, the slot diverts some of the air flowing along the lower surface of the at least one wing through the slot to flow over the upper surface of the trailing edge device, the lower surface of the at least one wing and the lower surface of the trailing edge device being shaped to provide an efficient cross section for a main structural box of the at least one wing; and

landing gear depending from the fuselage.

14. The aircraft of claim 13 wherein the at least one wing is at least approximately unswept.

15. The aircraft of claim 13 wherein the slot is configured to remain open at all flight conditions.

16. The aircraft of claim 13 wherein the at least one wing is configured to operate at a cruise Mach number of 0.78 or higher.

17. The aircraft of claim 13 wherein the at least one spar includes a forward spar and an aft spar forming portions of opposing sides of a wing box.

18. The aircraft of claim 13 wherein the at least one wing includes a forward spar and an aft spar and wherein at least one of the forward and aft spars is at least approximately unswept.

19. The aircraft of claim 13 wherein the at least one spar extends in an at least generally straight line from one side of the fuselage to the other.

20. The aircraft of claim 13 wherein the at least one wing includes a single wing having a common structure extending from a first side of the fuselage to a second side of the fuselage.

21. The aircraft of claim 13 wherein the at least one wing includes a single wing having a unitary structure extending from a first side of the fuselage to a second side of the fuselage.

22. The aircraft of claim 13 wherein the at least one wing includes a structure extending from a first side of the fuselage to a second side of the fuselage without a splice.

23. The aircraft of claim 13 wherein the slot extends over less than an entire span of the at least one wing.

24. The aircraft of claim 13 wherein the wing includes an aileron, and wherein the slot extends spanwise through a region of the at least one wing containing the aileron.

25. The aircraft of claim 13 wherein the at least one wing includes a single wing extending from a first tip on a first side of the fuselage to a second tip on a second side of the fuselage, and wherein the at least one wing further includes forward and aft spars, the forward spar extending from a first position at least proximate to the first tip to a second position at least proximate to the second tip, the aft spar extending from a

third position at least proximate to the first tip to a fourth position at least proximate to the second tip.

26. The aircraft of claim 13 wherein the slot is a first slot, and wherein the trailing edge device is movable relative to the at least one wing to form a second slot forward of the first slot and divert additional air from the lower surface of the wing to the upper surface of the trailing edge device.

27. The aircraft of claim 13 wherein at least one of the upper surface and lower surface of at least one of the wing and the trailing edge device includes a composite material.

28. The aircraft of claim 13, further comprising a propulsion system depending from at least one of the at least one wing and the fuselage.

29. The aircraft of claim 13, further comprising an empennage aft of the at least one wing.

30. The aircraft of claim 13 wherein the slot is configured to divert air sufficient to increase a critical Mach number of the aircraft.

31. The aircraft of claim 13 wherein the slot is configured to divert air sufficient to increase a maximum cruise speed of the aircraft.

32. An aircraft, comprising:

a fuselage,

at least one wing attached to the fuselage, the at least one wing including:

a forward airfoil element having an upper surface and a lower surface;

at least one spar positioned within the forward airfoil element and extending in an at least generally straight line from one side of the fuselage to the other;

an aft airfoil element having an upper surface and a lower surface, the aft airfoil element being coupled to the forward airfoil element, the aft airfoil element having a leading edge spaced apart from a portion of the forward airfoil element with a slot positioned between the portion of the forward airfoil element and the leading edge of the aft airfoil element, the slot being configured to be open during cruise flight to divert some of the air flowing along the lower surface of the forward airfoil element to flow over the upper surface of the aft airfoil element;

a propulsion system depending from at least one of the at least one wing and the fuselage; and

landing gear depending from the fuselage.

33. The aircraft of claim 32 wherein the at least one wing is configured for a subsonic cruise speed of at least Mach 0.78.

34. The aircraft of claim 32 wherein the at least one wing has an at least approximately unswept leading edge.

35. The aircraft of claim 32 wherein the at least one spar is at least approximately unswept.

36. The aircraft of claim 32 wherein the slot is configured to divert air sufficient to increase a critical Mach number of the aircraft.

37. The aircraft of claim 32 wherein the slot is configured to divert air sufficient to increase a maximum cruise speed of the aircraft.

38. (Canceled)

39. The aircraft of claim 32 wherein the at least one wing includes a single wing having a unitary structure extending from a first side of the fuselage to a second side of the fuselage.

40. The aircraft of claim 32 wherein the slot extends over less than an entire span of the at least one wing.

41. The aircraft of claim 32 wherein the at least one wing includes an aileron, and wherein the slot extends spanwise through a region of the at least one wing containing the aileron.

42. An aircraft system, comprising:

at least one wing having an upper surface shaped to include at least one transonic region during cruise flight; and

a flap assembly that includes a forward airfoil element having an upper surface portion and a lower surface portion, and an aft airfoil element coupled to the forward airfoil element, the aft airfoil element having an upper surface portion and a lower surface portion, at least a part of the aft airfoil element being spaced apart from a part of the forward airfoil element by a fixed first slot, the first slot being configured to be open during cruise flight to divert some of the air flowing along the lower surface portion of the wing to flow over the upper surface portion of the aft airfoil element, the first slot having an aft-facing exit opening at an offset between the upper surface of the wing and the upper surface portion of the aft airfoil element, the offset being in the thickness direction, and wherein the forward airfoil element and the aft airfoil element are movable as a unit relative to the at least one wing to open a second slot between the forward airfoil element and the at least one wing, the forward and aft airfoil elements having a fixed angular relationship with each other when the second slot is open and when the second slot is closed.

43. The aircraft system of claim 42 wherein the at least one wing is shaped to be efficient at a transonic condition.

44. The aircraft system of claim 42, further comprising:

a fuselage coupled to the at least one wing,

a propulsion system depending from at least one of the at least one wing and the fuselage; and

landing gear depending from at least one of the at least one wing and the fuselage.

45. The aircraft system of claim 42 wherein the at least one wing is at least approximately unswept.

46. The aircraft system of claim 42 wherein the at least one wing overlaps the trailing edge assembly by three percent of a combined chord length of the at least one wing and the flap assembly when the flap assembly is stowed.

47. The aircraft system of claim 42 wherein the slot extends over less than an entire span of the at least one wing.

48. The aircraft system of claim 42 wherein the at least one wing includes an aileron, and wherein the slot extends spanwise through a region of the at least one wing containing the aileron.

49. (Canceled)

50. The aircraft system of claim 42 wherein the slot is configured to divert air sufficient to increase a critical Mach number of the aircraft.

51. The aircraft system of claim 42 wherein the slot is configured to divert air sufficient to increase a maximum cruise speed of the aircraft.

52. An aircraft system, comprising:

at least one wing having a leading edge, an upper surface, and a lower surface, the upper surface being shaped to include at least one transonic region during cruise flight; and

a trailing edge device carried by the at least one wing, the trailing edge device having an upper surface and a lower surface, the upper surface of the trailing edge device being recessed away from an aft-extended contour of the at least one wing upper surface in a thickness direction along its entire length when in a neutral, undeflected position, at least one of the at least one wing and the trailing edge device having a spanwise slot, the slot having an aft-facing exit opening at an offset between the upper surfaces of the at least one wing and the trailing edge device, the offset being in the thickness direction, the slot being configured to be open during cruise flight to divert some of the air flowing along the lower surface of the at least one wing to flow over the upper surface of the trailing edge device, the slot being positioned to increase a Mach number at which the at least one wing undergoes transonic drag rise by about 0.03 compared with a wing having generally similar shape without the slot, the Mach number corresponding to a component of flow travelling generally normal to the leading edge of the at least one wing.

53. The aircraft system of claim 52, further comprising:

a fuselage coupled to the at least one wing;

a propulsion system depending from at least one of the at least one wing and the fuselage; and

landing gear depending from at least one of the at least one wing and the fuselage.

54. The aircraft system of claim 52 wherein the at least one wing is shaped to be efficient at a transonic condition.

55. The aircraft system of claim 52 wherein the at least one wing is at least approximately unswept.

56. The aircraft system of claim 52 wherein the slot is configured to remain open at all flight conditions.

57. The aircraft system of claim 52 wherein the at least one wing includes at least one spar that is at least approximately unswept.

58. The aircraft system of claim 52 wherein the slot extends over less than an entire span of the at least one wing.

59. The aircraft system of claim 52 wherein the at least one wing includes an aileron, and wherein the slot extends spanwise through a region of the at least one wing containing the aileron.

60. The aircraft system of claim 52 wherein the slot is a first slot and wherein the trailing edge device includes a forward portion and an aft portion, the forward portion and the aft portion being movable as a unit relative to the at least one wing to form a second slot forward of the first slot and divert additional air from the lower surface of the at least one wing to the upper surface of the trailing edge device.

61. The aircraft system of claim 52 wherein the at least one wing overlaps the trailing edge device by a distance at least approximately equal to three percent of a combined chord length of the at least one wing and the trailing edge device.

62. An aircraft system, comprising:

at least one wing, the at least one wing having an upper surface and a lower surface;

an internal structure including at least one spar; and

an airfoil structure including a trailing edge device carried by the at least one wing, the trailing edge device having an upper surface and a lower surface, the upper surface of the trailing edge device being recessed away from an aft-extended contour of the at least one wing upper surface in a thickness direction along its entire length when in a neutral, undeflected, undeployed position, at least one of the at least one wing and the trailing edge device having a spanwise slot that allows airflow from the at least one wing to the trailing edge device, wherein during cruising flight of the at least one wing, the airfoil structure diverts some of the air flowing along the lower surface of the at least one wing through the slot to flow over the upper surface of the trailing edge device.

63. The aircraft system of claim 62 wherein the slot extends over less than an entire span of the at least one wing.

64. The aircraft system of claim 62 wherein the at least one wing includes an aileron, and wherein the slot extends spanwise through a region of the at least one wing containing the aileron.

65. A method for manufacturing an aircraft system, comprising coupling a trailing edge device to an aircraft wing, with the aircraft wing overlapping the trailing edge device by a distance at least approximately equal to three percent of a combined chord length of the aircraft wing and the trailing edge device, and with a spanwise slot positioned between at least part of the aircraft wing and at least part of the trailing edge device, the slot being configured to be open during cruise flight to divert some of the air flowing along a lower surface of the aircraft wing to flow over an upper surface of the trailing edge device, the upper surface of the trailing edge device being recessed away from an aft-extended contour of the aircraft wing upper surface in a thickness direction along its entire length when in a neutral, undeflected, undeployed position, the slot having an aft-facing exit opening at an offset between an upper surface of the aircraft

wing and the upper surface of the trailing edge device, the offset being in the thickness direction.

66. The method of claim 65, further comprising:

attaching the aircraft wing to a fuselage;

connecting a propulsion system to at least one of the aircraft wing and the fuselage; and

coupling landing gear to at least one of the aircraft wing and the fuselage.

67. The method of claim 65 wherein coupling a trailing edge device to an aircraft wing includes coupling the trailing edge device to an at least approximately unswept aircraft wing.

68. The method of claim 65, further comprising configuring the slot to remain open at all flight conditions.

69. The method of claim 65, further comprising supporting the aircraft wing with at least one spar that is at least approximately unswept.

70. The method of claim 65, further comprising positioning the slot to extend over less than an entire span of the aircraft wing.

71. The method of claim 65, further comprising attaching an aileron to the aircraft wing and positioning the slot to extend spanwise through a region of the aircraft wing containing the aileron.

72. A method for manufacturing an aircraft system, comprising:

coupling a trailing edge device to an aircraft wing; and

positioning a slot between at least part of the aircraft wing and at least part of the trailing edge device to increase a Mach number at which the aircraft wing undergoes transonic drag rise by about 0.03 compared with an aircraft

wing having a generally similar shape without the slot, the Mach number corresponding to a component of flow travelling generally normal to the leading edge of the aircraft wing, the slot being configured to be open during cruise flight to divert some of the air flowing along a lower surface of the aircraft wing to flow over an upper surface of the trailing edge device.

73. The method of claim 72, further comprising:

attaching the aircraft wing to a fuselage;

connecting a propulsion system to at least one of the aircraft wing and the fuselage; and

coupling landing gear to at least one of the aircraft wing and the fuselage.

74. The method of claim 72 wherein coupling a trailing edge device to an aircraft wing includes coupling a trailing edge device to an at least approximately unswept wing.

75. The method of claim 72, further comprising configuring the slot to remain open at all flight conditions.

76. The method of claim 72, further comprising supporting the aircraft wing with at least one spar that is at least approximately unswept.

77. The method of claim 72, further comprising positioning the slot to extend over less than an entire span of the aircraft wing.

78. The method of claim 72, further comprising attaching ailerons to the wing and positioning the slot to extend spanwise through a region of the wing containing the ailerons.

Copy of U.S. Application No. 10/671,435
which is a reissue application of
U.S. Patent 6,293,497

AIRPLANE WITH UNSWEPT SLOTTED CRUISE WING AIRFOIL

This application claims the benefit of U.S. Provisional Application No. 60/028,853, filed Oct. 22, 1996.

FIELD OF THE INVENTION

This invention relates to an aircraft configuration and, more particularly, to a commercial jet aircraft utilizing a slotted cruise airfoil and a wing with very low sweep compared to the sweep of more conventional jet aircraft, achieving the same cruise speed.

BACKGROUND OF THE INVENTION

This invention relates to an aircraft configuration utilizing improved laminar flow. If laminar flow is achieved, aircraft drag, manufacturing costs, and operating costs are substantially reduced. U.S. Pat. No. 4,575,030, entitled, "Laminar Flow Control Airfoil" by L. B. Gratzer, and is assigned to the assignee of this invention. The Gratzer patent provides information on development which includes, among other techniques, suction surfaces and slots to promote natural laminar flow over a main box region of a wing.

SUMMARY OF THE INVENTION

An aspect of the wing of this invention is that it incorporates a slotted cruise airfoil. Slotted cruise airfoil technology that we have developed allows us to produce an unswept, or substantially unswept, wing that achieves the same cruise speed as today's conventional airplanes with higher sweep.

This invention, this technology allows the wing boundary layer to negotiate a strong recovery gradient closer to the wing trailing edge. The result is about a cruise speed of Mach=0.78, but with a straight wing. It also means that for the same lift, the super velocities over the top of the wing can be lower. With very low sweep and this type of cruise pressure distribution, natural laminar flow can easily be obtained. Lower-surface Kruegcr flaps are installed to increase lift capability for low-speed operation and to protect the wing leading edge from bugs during takeoff and landing to prevent spoiling natural laminar flow.

In another aspect of the invention, heat is transferred from the leading edges of the wing and/or of the main flap to increase the extent of the natural laminar flow.

In still another aspect of this invention, a high wing arrangement allows more freedom for installation of higher bypass ratio engines. An advanced geared fan engine, by-pass ratio 12 or higher, is a possibility that could be easily installed under the high wing. The lower super velocities of the slotted cruise airfoil make the body shock problem associated with many high wing airplanes less of a concern here.

The slotted cruise wing airfoil and the straight wing allow us to modularize the wing and the body so that we can develop a family of airplanes by intermixing different bodies with different wings.

Another aspect of this invention is to reduce costs. The unsweeping of the wing significantly changes the manufacturing processes, reduces manufacturing costs and flow time from detail part fabrication to airplane delivery. The system architecture is all new rather than a major remodeling of a systems architecture from an exiting airplane. It is a top down approach geared towards the requirements of this airplane. Components from existing products will be used whenever they satisfy the requirements of this airplane. The payload systems allow for flexible interiors and extensive use of molded panels.

Still another aspect of this invention is that the expected fuel burn per seat for this type of an airplane is 20% to 30% less than on current jet airplanes, this can be associated with considerable reduction of emission of greenhouse gases.

There is very little difference in ditching capability between a low wing airplane and a high wing airplane. In both cases, the body provides the vast majority of the flotation. The wing provides some stability to prevent the ditched airplane from rolling over.

Another aspect of this invention is that a low wing version with aft mounted engines is also possible. It would feature many, if not most of the above advantages.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. *1a* through *1c* compare the straight wing arrangements with the conventional wing.

FIGS. *2a* through *2c* compare the effect of the straight wing on the configurations with the conventional wing.

FIG. 3 is an isometric view of the high wing version of FIGS. 1 and 2 with a 'T'-tail.

FIG. 4 is an isometric view of the high wing version of FIGS. 1 and 2 with an alternative 'V'-tail empennage arrangement.

FIG. 5 is an isometric view of the low wing version of FIGS. 1 and 2.

FIGS. *6a* and *6b* illustrate the details of the slotted airfoil.

FIGS. *7a* and *7b* compare the pressure distributions for a conventional airfoil and slotted airfoil (*7a* is conventional).

FIG. 8 shows a drag rise comparison between a conventional airfoil and a slotted airfoil.

FIG. 9, the pie-chart illustrates the recurring cost distribution for a conventional wing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The illustrations on FIGS. 1 and 2 serve for the explanation between an existing, prior art airplane configuration as a reference, and two different new arrangements that are the subject of this patent application.

On the prior art reference airplane, FIGS. *1a* and *2a*, a swept wing 1 is attached to the bottom of the fuselage 5. The basic components of the wing 1 consist of a structural box, which is divided into a left-hand exposed part 2, a center section 3, and a right-hand exposed part 4. Medium bypass ratio engines 6 are attached to struts 7 below the wing. The main landing gear 8 is suspended from the wing 1. Its support by means of a trunnion requires space within a wing trailing edge extension 9, also called a 'Yehudi'. Wing leading edge devices 10 are of the common type, slats or Krueger flaps or a combination thereof. Trailing edge devices are flaps 11, spoilers 12 and ailerons 13. The length of the main landing gear 8 is determined by engine 6 ground clearance and rotation angle of the airplane. The aft fuselage 5 also shows an 'upsweep' angle 36 for airplane rotation during take-off and landing.

On the 'high wing' example of the invention, FIG. *1b* and *2b*, an unswept wing 14 is attached to the top of the fuselage 15. Its structural box 16 is a single part, reaching from wing tip to wing tip. It is formed by the rear spar 39, front spar 82, upper 83 and lower 84 wing skins. Additional spars in intermediate positions between the rear spar 39 and the front

spar 82 could also be included. High bypass ratio engines 17 are attached to struts 18 below the while. The main landing gear 19 is attached to the fuselage 15, not requiring additional space in the wing platform 14. Wing leading edge devices 20 are Krueger flaps. Spoilers 21 are of the same type as on the reference airplane. However, the flaps 23 represent the 'vane-main' feature with the addition of a slot that is permanent for all flap positions and is a unique key to this invention. More detail is shown on FIG. 6. The slots are extended outboard throughout the ailerons 22. Heat is transferred from the leading edge of the wing 14 and/or of the main flap 23 to increase the extent of natural laminar flow. The Main landing gear 19 is shorter than the gear on the reference airplane. The aft fuselage 15 is more symmetric, ends in a vertical blade shape, and features less upsweep angle 37 and less drag than on the reference airplane due to the features of the 'slotted wing' 14. Compared to a low wing, the high wing 14 allows for a better distribution of the cast Aluminum passenger doors 24, with unobstructed escape slides. The lower deck cargo compartment 25 capacity is also increased because of the absence of the wing box.

On the 'low wing' example of the invention, FIGS. 1*c* and 2*c*, an unswept wing 26 is attached to the bottom of the fuselage 27. Its structural box 28 is a single part, reaching from tip to tip. High bypass ratio engines 29 are attached to struts 30 at both sides of the aft fuselage 27. The main landing gear 31 is attached to the fuselage 27, of requiring additional space in the wing platform 26. Wing leading edge devices 20, spoilers 21 and ailerons 22 are of the same type and shape as on the previous airplane. The flaps 23 represent the 'vane-main' feature with the addition of a slot that is permanent for all flap positions and is a unique key to this invention. More detail is shown on FIG. 6. These are of the same type and shape as on the previous airplane. The slots are also extended outboard throughout the ailerons. Heat is transferred from the leading edge of the wing 26 and/or of the main flap 23 to increase the extent of natural laminar flow. The main landing gear 31 is shorter than the gear on the reference airplane. The aft fuselage 27 is more symmetric, ends in a vertical blade shape, and features less upsweep angle 38 and less drag than on the reference airplane due to the features of the 'slotted wing' 26. Basically, the shape and size of the wing 26 and the fuselage 27 are similar to the airplane in FIGS. 1*b* and 2*b*.

The embodiments of the whole airplane configurations are shown on FIGS. 3 through 5. All three figures represent examples of this invention.

FIG. 3 is an isometric view of the high wing version, FIGS. 1*b* and 2*b*. The empennage arrangement resembles a 'T'-tail 32. The nose landing gear 33 is shorter than on the Reference airplane, because of the close ground proximity.

FIG. 4 is another isometric view of the high wing 14 version, FIGS. 1*b* and 2*b* with an alternative empennage arrangement. The 'T'-tail arrangement of FIG. 3 has been replaced by a 'V'-shape 34.

FIG. 5 is an isometric view of the low wing 26 version, FIGS. 1*c* and 2*c*. The nose landing gear 35 is shorter than on the reference airplane, because of the close ground proximity.

FIG. 6 is extracted from the concurrent patent application Ser. No. 08/735,233, filed Oct. 22, 1996 entitled, "Slotted Cruise Trailing Edge Flap" by G. L. Siers. The two views, FIG. 6*a* and 6*b* illustrate the two extreme positions of the trailing edge flap.

Of particular interest is the wing rear spar 39 shown in combination with the rear fragment of a wing 14 or 26. The components of the flap 23 are generally located aft of, and are structurally supported by, the wing rear spar 39.

In general, a slotted cruise trailing edge flap 23 formed in accordance with the application Ser. No. 08/735,233 has a single-slotted configuration during cruise, FIG. 6*a* and a double-slotted configuration during takeoff(not shown) and landing, FIG. 6*b*. This is accomplished by a flap assembly 23 that is movable between a stowed position and an extended position. In the stowed position a single slot is present, and in the extended position two slots are present. More specifically, flap assembly 23 includes two airfoil elements, a vane element and a main element, that are arranged in fixed relation to one another. The space between the airfoil elements forms a permanent single slot. At various support locations along the wing trailing edge, the flap assembly 23 is movably connected to an extension assembly 40 that is secured to the wing rear spar 39.

The extension assembly 40 includes a support structure to which the flap assembly 23 is translatable and rotatably connected. The extension assembly 40 further includes an actuation mechanism that moves the flap assembly 23 relative to the support structure. In a stowed position, the vane element of flap 23 nests into the wing 14 or 26 such that the permanent single slot remains available to direct airflow from regions below the wing to regions above the wing. In an extended position, the vane and main elements of flap 23 form a double-slotted arrangement by rotating downward and translating rearward relative to the wing 14 or 26.

Physical factors limiting the performance of transonic cruise airfoils

In the following discussion, "airfoil" refers to the cross-sectional shape of a wing in planes that are substantially longitudinal and vertical, which plays a major role in determining the aerodynamic performance of said wing. "Transonic cruise" refers to operation of the wing at high subsonic speed such that the airflow past the wing contains local regions of supersonic flow. "Mach number" refers to the ratio of the flow speed to the speed of sound.

The performance of an airfoil in transonic cruise applications can be characterized by four basic measures:

1) The airfoil thickness, usually expressed as the maximum-thickness ratio (maximum thickness divided by chord length). Thickness is beneficial because it provides the room needed for fuel and mechanical systems and because a wing structure with greater depth can be lighter for the same strength.
2) The speed or Mach number at the preferred operating condition The Mach number capability of the airfoil, modified by a factor related to the sweep angle of the wing, contributes directly to the cruise speed of the airplane.
3) The lift coefficient at the preferred operating condition. Increased lift coefficient is advantageous because it could allow increased weight (e.g. more fuel for longer range) or a higher cruise altitude.
4) The drag coefficient at the preferred operating condition and at other operating conditions that would be encountered in the mission of an airplane. Reducing the drag reduces fuel consumption and increases range.

Other measures such as the pitching-moment characteristics and the lift capability at low Mach numbers are also significant, but are less important than the basic four.

Together, the four basic performance measures define a level of performance that is often referred to as the "technology level" of an airfoil. The four basic performance measures impose conflicting requirements on the designer in

the sense that design changes intended to improve one of the measures tend to penalize at least one of the other three. A good design therefore requires finding a favorable compromise between the four measures.

At any given technology level, it is generally possible to design a wide range of individual airfoils tailored to different preferred operating conditions and representing different trade-offs between the four basic performance measures. For example, one airfoil could have a higher operating Mach number than another, but at the expense of lower lift and higher drag. Given modern computational fluid dynamics tools, designing different airfoils at a given technology level is generally a straightforward task for a competent designer. On the other hand, improving the technology level, say by improving one of the basic performance measures without penalizing any of the other three, tends to be more difficult, and the more advanced the technology level one starts with, the more difficult the task becomes. Starting with an airfoil that is at a technology level representative of the current state of the art, it can be extremely difficult to find significant improvements.

The main factors that limit performance are associated with the physics of the flow over the upper surface of the airfoil. To understand these factors, it helps to look at a typical transonic cruise airfoil pressure distribution, plotted in terms of the pressure coefficient C_P on a negative scale, as shown in FIG. 7(*a*). For reference, the shape of the airfoil is shown just below the pressure-distribution plot. On the C_P scale shown, C_P=0 is the static pressure of the freestream flow far from the airfoil, which is assumed to be at a subsonic speed. At each point on the surface, the value of C_P, in addition to defining the pressure, corresponds to a particular value of the floss velocity just outside the thin viscous boundary layer on the surface. Negative C_P (above the horizontal axis) represents lower pressure and higher velocity than the freestream, while positive C_P (below the horizontal axis) corresponds to higher pressure and lower velocity. A particular level of negative C_P corresponds to sonic velocity and is shown by the dotted line **41**.

The lower curve **42** on the pressure-distribution plot represents the pressure on the lower surface **43**, or high-pressure side, and the upper curve **44** represents pressure on the upper-surface **45**. The vertical distance between the two curves indicates the pressure difference between the upper and lower surfaces, and the area between the two curves is proportional to the total lift generated by the airfoil. Note that near the leading edge there is a highly positive spike in the C_P distribution **46** at what is called the "stagnation point" **47**, where the oncoming flow first "attaches" to the airfoil surface, and the flow velocity outside the boundary layer is zero. Also, note that the upper- and lower-surface C_P distributions come together at the trailing edge **48**, defining a single value of C_P **49** that is almost always slightly positive. This level of C_P at the trailing edge, as will be seen later, has an important impact on the flow physics. Because the trailing-edge C_P is dictated primarily by the overall airfoil thickness distribution, and the thickness is generally constrained by a number of structural and aerodynamic factors, trailing-edge C_P is something over which the designer has relatively little control. Away from the leading-edge stagnation point and the trailing edge, the designer, by varying the airfoil shape, has much more control over the pressure distribution.

For a given airfoil thickness and Mach number, the problem of achieving a high technology level boils down to the problem of maximizing the lift consistent with a low drag level. Increasing the lift solely by increasing the lower-surface pressure is generally not possible without reducing airfoil thickness. Thus the designer's task is to reduce the upper-surface pressure so as to produce as much lift as possible, but to do so without causing a large increase in drag. In this regard, the pressure distribution shown in FIG. (*7a*) is typical of advanced design practice. The operating condition shown is close to the preferred operating condition that might be used for the early cruise portion of an airplane mission. The drag at this condition is reasonably low, but at higher Mach numbers and/or lift coefficients, the drag would increase rapidly.

Note that the upper-surface C_P **44** over the front half of the airfoil is above the dotted line **41**, indicating that the flow there is mildly supersonic. Just aft of midchord, this supersonic zone is terminated by a weak shock, indicated on the surface as a sudden increase in C_P **50** to a value characteristic of subsonic flow. The C_P distribution in the supersonic zone **51** is deliberately made almost flat, with only an extremely gradual pressure rise, in order to keep the shock from becoming stronger and causing increased drag at other operating conditions. The shock is followed by a gradual pressure increase **52**, referred to as a "pressure recovery", to a slightly-positive C_P **49** at the trailing edge. The location of the shock and the pressure distribution in the recovery region are carefully tailored to strike a balance between increased lift and increased drag.

Trying to increase the lift will tend to move the airfoil away from this favorable balance and increase the drag. For example, one way of adding lift would be to move the shock **50** aft. This, however, would require a steeper recovery (because the immediate post-shock C_P and the trailing-edge C_P are both essentially fixed), which would cause the viscous boundary layer to grow thicker or even to separate from the surface, either of which would result in a significant drag increase. The other obvious way to increase lift would be to lower the pressure ahead of the shock even further (move the C_P curve **51** upward over the forward part of the airfoil and increase the supersonic flow velocity there), but this would increase the pressure jump across the shock, which would result in an increase in the so-called shock drag. For single-element transonic airfoils at the current state of the art, this compromise between lift and drag has reached a high level of refinement, and it is unlikely that any large improvement in technology level remains to be made.

Potential technology advantage of the slotted airfoil

The shape and resulting pressure distribution of a slotted transonic cruise airfoil are shown in FIG. (**6**) and (*7b*). The airfoil **23** consists of two elements (a forward element **60** and an aft element **61**) separated by a curved channel (**62**, the slot) through which air generally flows from the lower surface **84** to the upper surface **64**. In this example, the slot lip (**65**, the trailing edge of the forward element) is just aft of 80 percent of the overall chord from the leading edge, and the overlap of the elements is about 3 percent of the overall chord. Pressure distributions are shown for both elements, so that the pressure distributions overlap where the airfoil elements overlap. As with the conventional airfoil, the upper curves **66**,**67** give the C_P distributions on the upper surfaces **64**,**83**, and the lower curves **68**,**69** give C_P on the lower surfaces **84**,**70**. Note that there are two stagnation points **71**,**72** and their corresponding high-pressure spikes **73**,**74**, one on each element, where the oncoming flow attaches to the surface near each of the leading edges.

To begin the consideration of the flow physics, note that the preferred operating condition for the slotted airfoil shown is faster than that of the single-element airfoil (Mach 0.78 compared with 0.75), and that the lift coefficient is

slightly higher, while both airfoils have the same effective thickness for structural purposes. At the slotted airfoil's operating condition, any single-element airfoil of the same thickness would have extremely high drag. The slotted airfoil's substantial advantage in technology level results from the fact that the final pressure recovery 75 is extremely far aft, beginning with a weak shock 76 at about 90 percent of the overall chord. Such a pressure distribution would be impossible on a single-element airfoil because boundary-layer separation would surely occur, preventing the shock from moving that far aft. The mechanism, loosely termed the "slot effect", by which the slot prevents boundary-layer separation, combines several contributing factors:

1) The boundary layer on the upper surface 83 of the forward element is subjected to a weak shock 77 at the slot lip 65, but there is no post-shock pressure recovery on the forward element. This is possible because the aft element 61 induces an elevated "dumping velocity" at the trailing edge of the forward element (The trailing-edge C_p 78 on the forward element is strongly negative, where on a single-element airfoil the trailing-edge C_p is generally positive).
2) The upper- and lower-surface boundary layers on the forward element combine at the trailing edge 65 to form a wake that flows above the upper surface 64 of the aft element and that remains effectively distinct from the boundary layer that forms on the upper surface of the aft element. Over the of part of the aft element, this wake is subjected to a strong pressure rise 75,76, but vigorous turbulent mixing makes the wake very resistant to flow reversal.
3) The boundary layer on the upper surface 64 of the aft element has only a short distance over which to grow, starting at the stagnation point 72 near the leading edge of the aft element, so it is very thin when it encounters the final weak shock 76 and pressure recovery 75, and is able to remain attached. With regard to its pressure distribution and boundary-layer development, the aft element is, in effect, a separate airfoil in its own right, with a weak shock and pressure recovery beginning at about the mid-point of its own chord, for which we would expect attached flow to be possible.

The upper-surface pressure distribution of FIG. 7(*b*) is a relatively extreme example of what the slot effect makes possible. A range of less-extreme pressure distributions intermediate between that shown in FIG. 7(*b*) and the single-element pressure distribution of FIG. 7(*a*) can also take advantage of the slot effect. The shock on the forward element does not have to be all the way back at the slot lip, and there does not have to be a supersonic zone on the upper surface of the aft element. In fact, the airfoil of FIG. 7(*b*) displays a sequence of such intermediate pressure distributions when operating at lower Mach numbers and lift coefficients than the condition shown. The slot effect is still needed to prevent flow separation at these other conditions.

One way of comparing the technology levels of airfoils is to plot the drag-rise curves (drag coefficient versus Mach number at constant lift coefficient), as shown in FIG. (8). Here the dashed curve 80 is for the single-element airfoil of FIG. 7(*a*) at a lift coefficient Cl of 0.75, and the solid curve 81 is for the slotted airfoil of FIG. 7(*b*) at a slightly higher Cl of 0.76. It is clear that the low-drag operating range of the slotted airfoil extends up to 0.03 Mach faster than the single-element airfoil, with slightly higher lift and the same thickness. Of course the slotted airfoil could be redesigned to use this technology advantage for purposes other than higher speed, for example, to achieve even higher lift at the same speed as the single-element airfoil.

The pressure distribution on the lower surface also contributes to the technology level of the slotted airfoil of FIG. 7(*b*). Compare the pressure distribution 68 on the lower surface 84 of the forward element of the slotted airfoil with the corresponding pressure distribution 42 on the lower surface 43 of the single-element airfoil of FIG. 7(*a*). The flatter pressure distribution on the slotted airfoil results in less curvature of the lower surface of the airfoil and greater depth of the airfoil at the locations where the front and rear spars of the main structural box would be placed (typically about 15 percent and 64 percent of the overall chord). Flatter lower-surface skins and deeper spars are both favorable to the structural effectiveness of the main box structure. In the design of the airfoil of FIG. 7(*b*) this advantage was traded so as to contribute to the improved Mach number and lift coefficient, while keeping the structural effectiveness (bending strength) of the wing box the same as that of the single-element airfoil of FIG. 7(*a*).

The unsweeping of the wing significantly changes the manufacturing processes, reduces manufacturing costs and flow time from detail part fabrication to airplane delivery. Conventional commercial jet airplane wings are built with structural splices where the stringers and spars change direction, generally at the side of body. With an unswept wing, one of the spars has no changes in direction and no splice. Wing box structural stringers (skin panel stiffeners) are parallel to the straight spar and do not have splices. As with the spar and stringers, the wing structural skin does not require spanwise splicing although chord wise splicing will be used when the limits of raw material make single piece wing skins impractical. Building the wing as a single piece rather than a left wing a right wing and a wing stub eliminates the parts associated with splicing and the labor and flow time required to join the left and right wing to the wing stub. Significant reductions in the quantity of parts and manufacturing labor are a result of unsweeping the wing. FIG. 9 represents conventional wing recurring costs, the outboard wing cost represented by 91 will be reduced by 30%. This savings is the combination of eliminating the wing joints, and the reduction of wing shear and dihedral. Another 12% cost reduction could be realized with low cost graphite construction. The wing stub cost represented by 92 will be reduced by 90% because it is not required.

Unsweeping the wing 14 changes the wing relationship with the main landing gear 19. Conventional swept wing commercial jet airplanes integrate the landing gear into the portion of the wing aft of the rear spar 9. With the unswept high wing commercial jetliner configuration shown in FIGS. 1 through 5, the landing gear 19 is not integrated into the wing at all, reducing the plan area of the wing and simplifying the wing aft of the rear spar 9. The cost reduction is relative to FIG. 9, the recurring cost of the fixed trailing edge (the non-moving parts of the wing aft of the rear spar) represented by 93 is reduced by 25%. One disadvantage of reducing the area of the fixed trailing edge is the reduction in wing thickness at the rear spar 39. This may result in a requirement for a mid spar or spars with more depth. The spoilers 21, fixed leading edge, moveable leading edge 20 and moveable trailing edge 23 costs represented by 94 are not expected to change. The additional cost associated with designing the slot 62 into the airfoil is expected to be offset by the elimination of an inboard aileron and the simplification of the high lift system.

Structural design advantages of the unswept wing include higher loading of the front spar 82 and thereby unloading the rear spar 39 and aft part of the wing skins 83 and 84. This load redistribution results in the ability to increase the

structural aspect ratio of the wing while maintaining the same stress levels. Utilizing a mid spar or spars may increase the wing aspect ratio further with out increasing stress levels.

The slotted cruise wing airfoil and the straight wing allow us to modularize the wing 14 and the body 15, so that we can develop a family of airplanes by intermixing different bodies with different wings.

Aspect Ratio is the ratio of $(\text{span})^2$ divided by wing area. Structural Aspect Ratio is the ratio of $(\text{structural span})^2$ divided by structural wing area.

While preferred embodiments of the invention have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A commercial jetplane capable of flying at a cruise speed of Mach=0.78 or above, comprising:

a fuselage;

a landing gear mounted on said fuselage;

a single wing attached to said fuselage, said single wing being substantially unswept with a high aspect ratio, and including:

a forward airfoil element having an upper surface and a lower surface;

an aft airfoil element having an upper surface and a lower surface;

an internal structure comprising at least two spars extending from one tip to an opposing tip of said single wing, with a rear one of the spars being straight and unswept in plan view;

an airfoil structure having a slot that allows airflow from the forward airfoil element to the aft airfoil element, wherein during cruising flight of the airplane, said airfoil structure having said slot diverts some of the air flowing along the lower surface of the forward airfoil element to flow over the upper surface of the aft airfoil element, and where the lower surface of the forward airfoil element and the lower surface of the aft airfoil element are shaped to provide an efficient cross section for a main structural box of the single wing; and

said wing and said fuselage being constructed of at least one of aluminum and graphite composite.

2. The airplane of claim 1 wherein said airfoil structure having a slot produces natural laminar flow over the aft airfoil element of said single wing.

3. The airplane of claim 1 wherein said airfoil structure having said slot produces natural laminar flow over the forward airfoil element of said single wing.

4. The airplane of claim 1 wherein heat is transferred from a leading edge of at least one of said wing and main flap to increase the extent of said natural laminar flow.

5. An airplane of claim 1 which comprises a "T"-tail type empennage.

6. The airplane of claim 1 which comprises a "V"-tail type empennage.

7. The airplane of claim 1 which comprises a low tail type empennage.

8. The airplane of claim 7, wherein at least two high bypass ratio engines are attached to the airframe.

9. The airplane of claim 8 wherein said high bypass engines are geared fan engines or unducted fans which are energy efficient with reduced fuel consumption, noise and greenhouse gas emissions.

10. The airplane of claim 1 wherein the reduced rotation angle also decreases the aft body upsweep and reduces drag.

11. An airplane of claim 1 wherein said single wing is attached to the top of said fuselage and the engines are attached below the wing.

12. An airplane of claim 1 wherein said single wing is attached to the bottom of said fuselage and said engines are attached to the aft end of the fuselage.

* * * * *

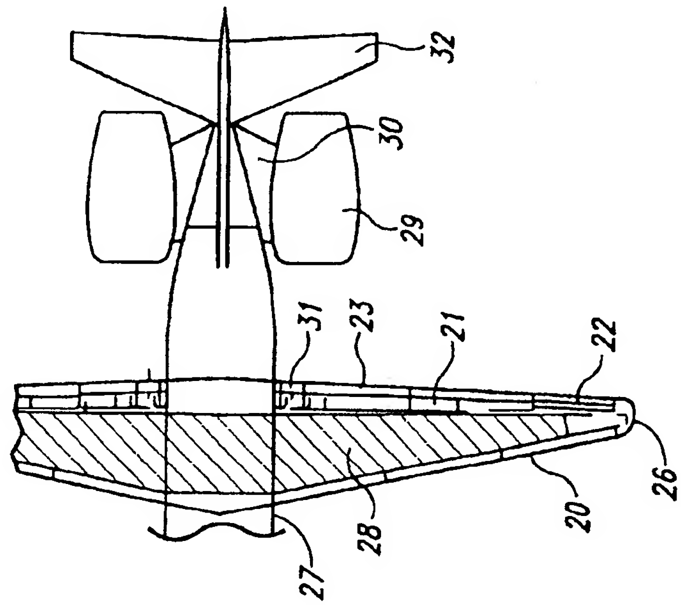


Fig. 1C

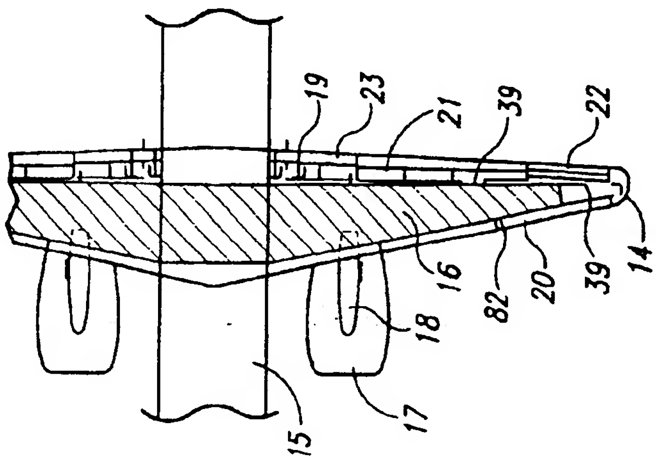


Fig. 1B

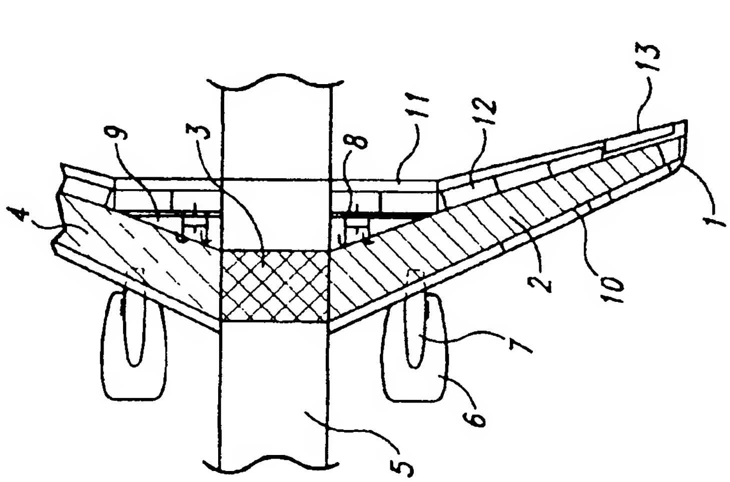


Fig. 1A
(Prior Art)

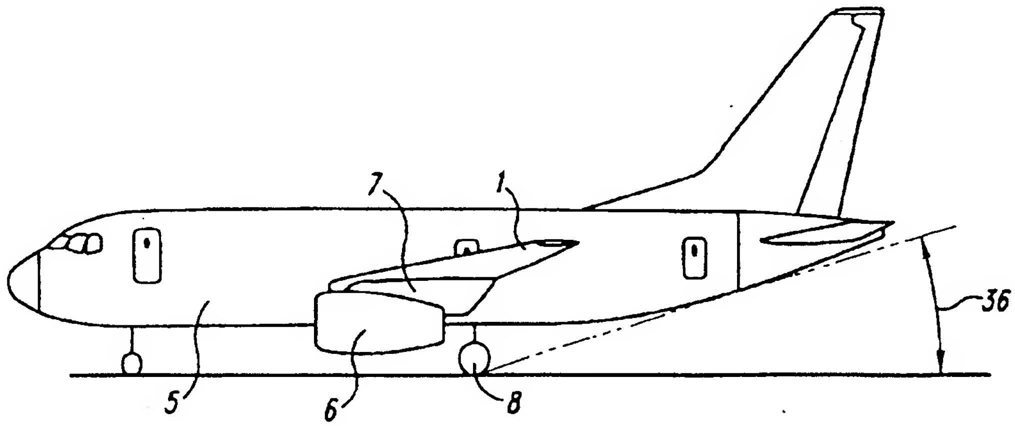


Fig. 2A
(Prior Art)

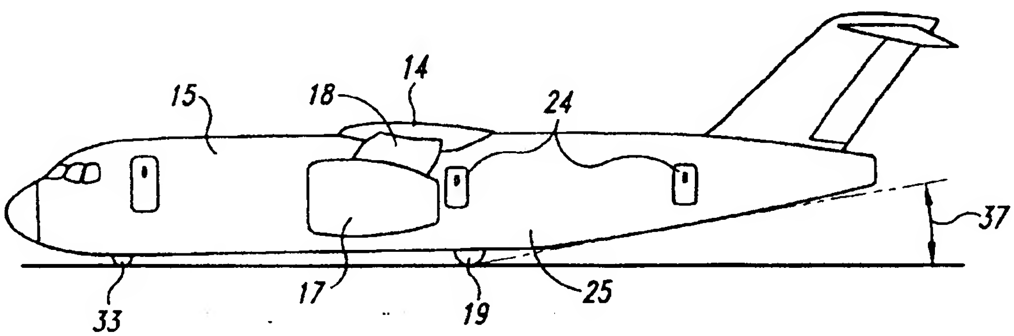


Fig. 2B

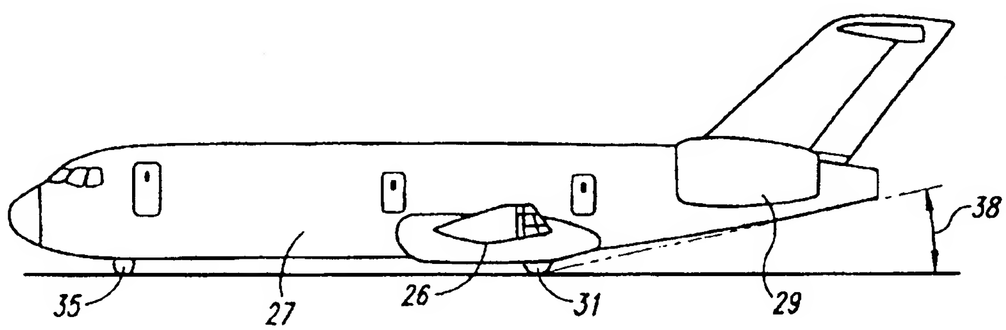


Fig. 2C

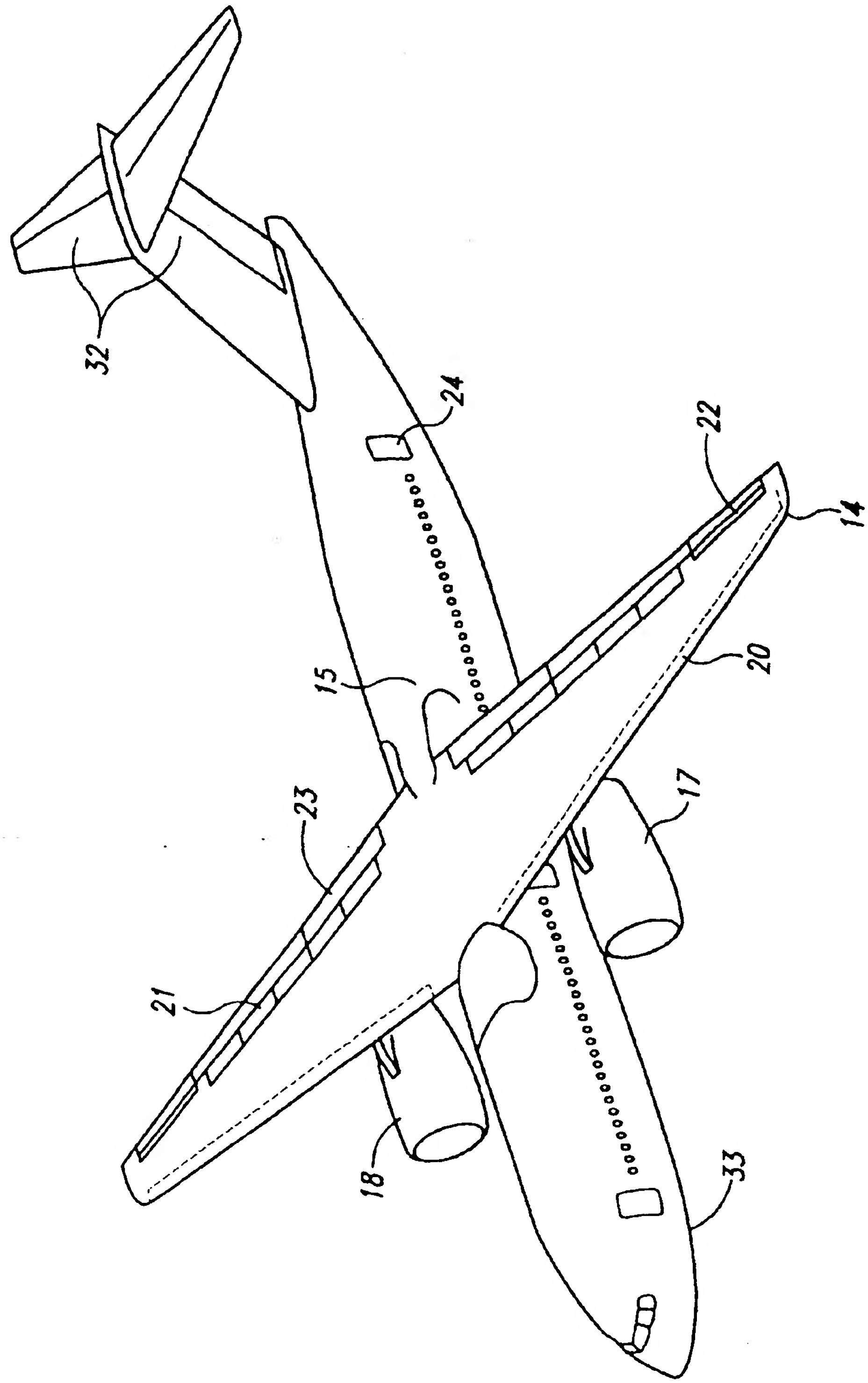


Fig. 3

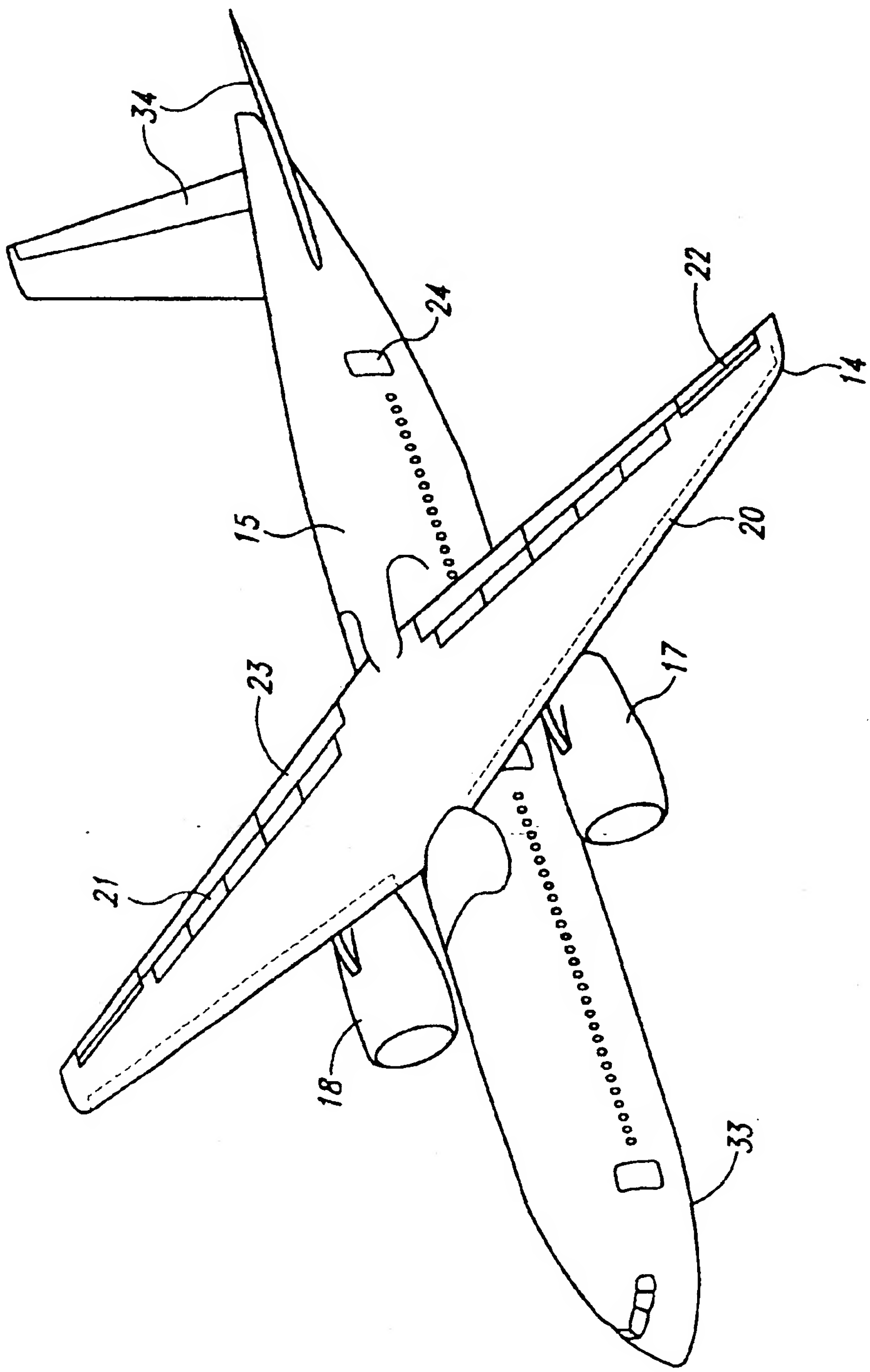


Fig. 4

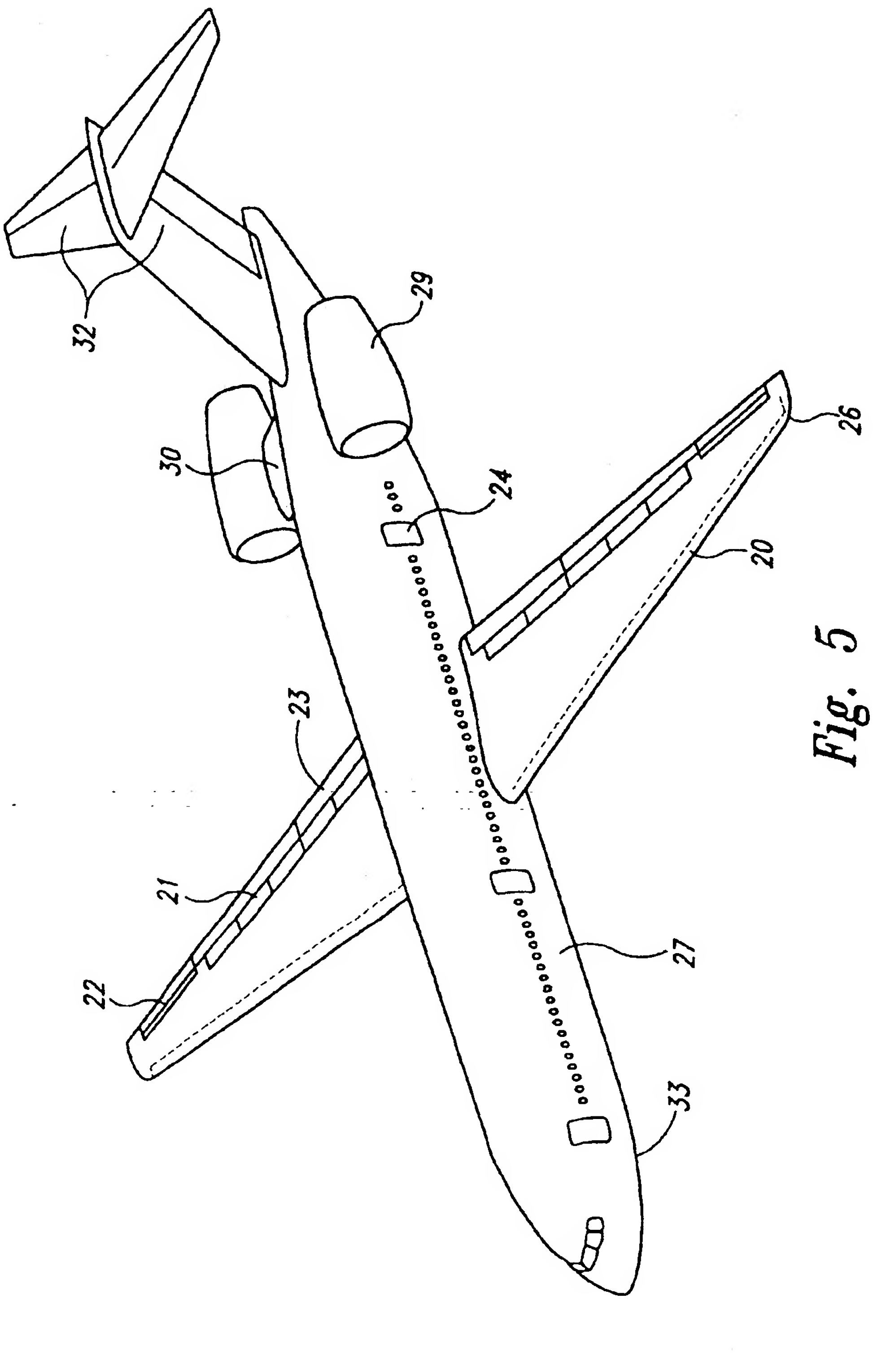


Fig. 5

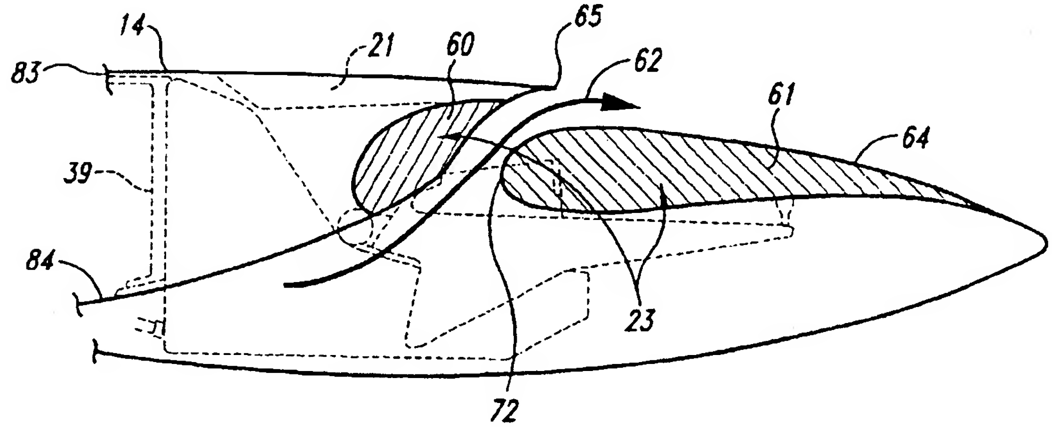


Fig. 6A

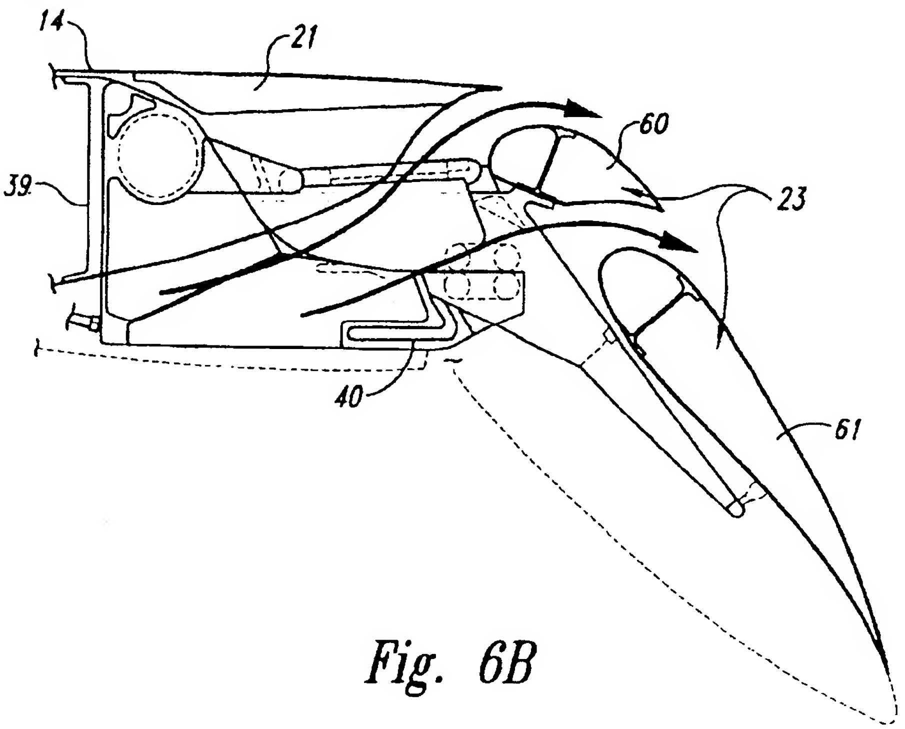
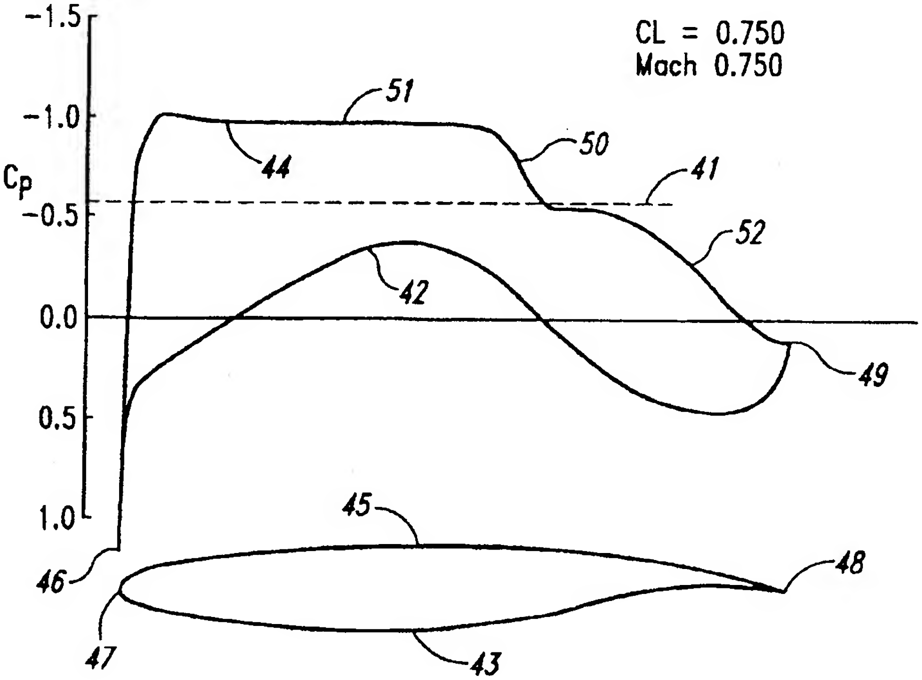


Fig. 6B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43

Fig. 7A

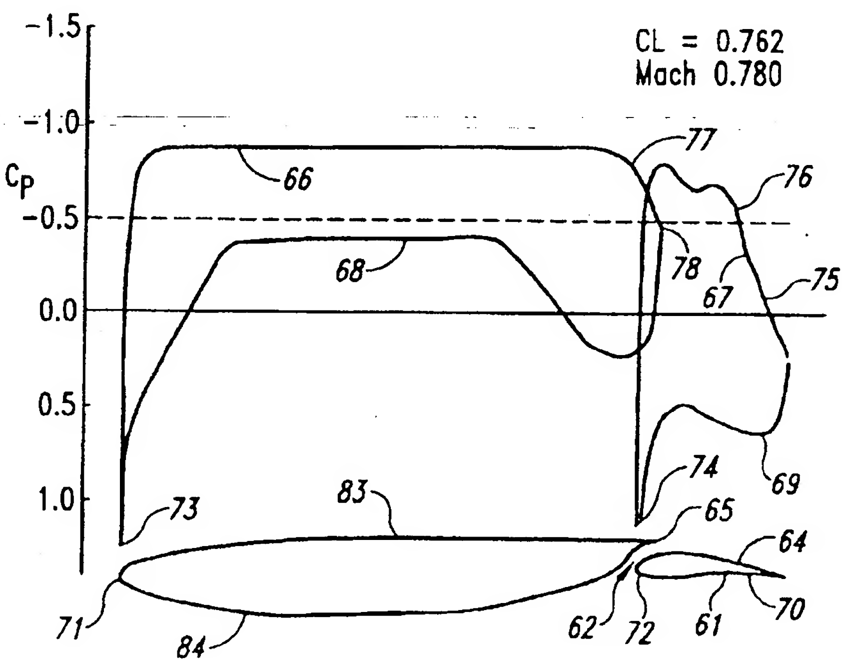
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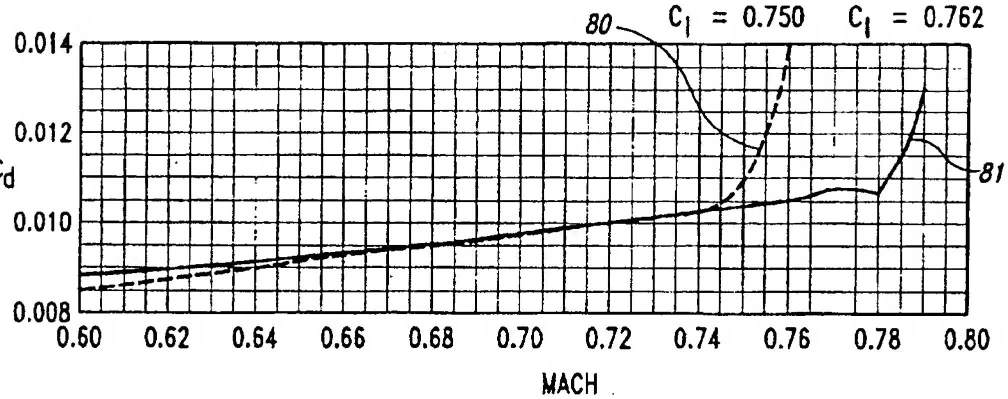
Fig. 7B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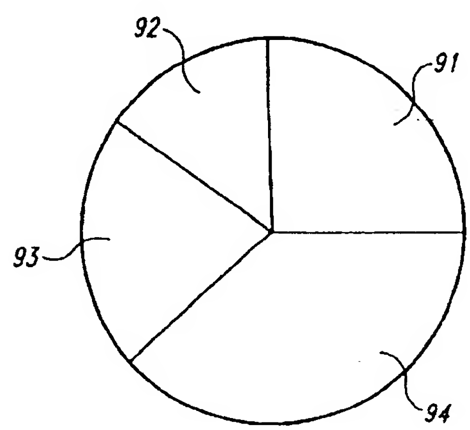
MACH
81

Fig. 8


92
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93
94

Fig. 9

EXHIBIT D

Copy of signed Domestic Return Receipt by Theresa H. McLean

SENDER: COMPLETE THIS SECTION	**COMPLETE THIS SECTION ON DELIVERY**
■ Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired. ■ Print your name and address on the reverse so that we can return the card to you. ■ Attach this card to the back of the mailpiece, or on the front if space permits.	A. Signature X Theresa H. McLean ☐ Agent ☐ Addressee B. Received by (*Printed Name*) Theresa H. McLean C. Date of Delivery
1. Article Addressed to: ATTN: James Douglas McLean 7004 South 130th Street Seattle, WA 98178-4718	D. Is delivery address different from item 1? ☐ Yes If YES, enter delivery address below: ☐ No SKYWAY STATION SEATTLE WA 98178 NOV 16 2011 USPS
	3. Service Type ☒ Certified Mail ☐ Express Mail ☐ Registered ☐ Return Receipt for Merchandise ☐ Insured Mail ☐ C.O.D.
	4. Restricted Delivery? (*Extra Fee*) ☐ Yes

2. 7010 0290 0000 7400 7698

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

UNITED STATES POSTAL SERVICE WA 981

16 NOV 2011 PM 2 T

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